Childcare Choices and Early Cognitive Development

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Vladislav Valeriev Slanchev

Department of Economics
Duke University

Date: _____

Approved:

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V. Joseph Hotz, Supervisor

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Peter Arcidiacono

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Seth G. Sanders

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Federico Bugni

Dissertation submitted in partial fulfillment of the requirements for the degree of
Doctor of Philosophy in the Department of Economics
in the Graduate School of Duke University
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Abstract

This study uses the data from the National Institute for Children Health and Development Study of Early Child Care and Youth Development to evaluate features of wage and childcare price changes that are associated with positive effects on children's early cognitive skills. Identifying beneficial characteristics of changes in market variables is especially relevant in a policy environment where the main priority of tax incentives related to the use of childcare is not facilitating the formation of children's cognitive skills, but reducing reliance on the welfare system through an increase in employment among poor households.

We estimate jointly the discrete household choices related to the employment status of the mother and the use of a paid care mode, the demand functions for quantity and quality of childcare, the production function for cognitive outcomes, the wage process for the mother, and the childcare price equations based on the hedonic pricing method, while at the same time introducing unobserved heterogeneity in the disturbance terms of the estimated outcomes. Our strategy for handling selection problems also utilizes the exogenous variation in childcare prices across the 10 geographic markets for childcare services defined by the study sites in the NICHD SECCYD dataset, which in our model influence choices, but do not affect cognitive outcomes directly.

Our results show that failing to account for common unobserved characteristics would lead to underestimating the impact of all analyzed wage and price changes. We

find that prices and wages do not have a statistically significant impact on the quality of paid care, while the marginal product of that attribute of care is positive for almost all input combinations in the production of cognitive attainment. Therefore, a policy utilizing changes in wages and prices can be effective in improving early cognitive skill only through the impact of those changes on the intensity of paid care use.

The comparison of the effects of wage and price changes on early cognitive skills for three sets of values of the observable household characteristics representing low, middle and high income households lead to the following conclusions: (1) a tax credit for working mothers and childcare subsidies for center-based care can bring disproportionate gains for children in low and middle income groups; (2) subsidizing paid home care for children less than three and a half years old can be more effective than subsidizing center-based care for the same age group in terms of improving cognitive outcomes at the age of five; (3) conditioning childcare assistance for paid care on the employment status of the mother does not seem to have a strong negative effect on early skill formation; and (4) tax incentives affecting wage rates and childcare prices prove to be beneficial for the formation of early cognitive skills only when they are implemented while the child is less than three and a half years old.

To Irina, the love of my life.

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List of Abbreviations

CCDF	Child care and development fund
CPI	Consumer Price Index
ECERS	Early Care Environment Rating Scale
EITC	Earned Income Tax Credit
FDCRS	Family Day Care Rating Scale
HOME	Home Observation for Measurement of the Environment
ITERS	Infant/Toddler Environment Rating Scale
NICHD SECCYD	National Institute for Child Health and Development Survey of Child Care and Youth Development
NLSY	National Longitudinal Study of Youth
PPVT-R	Peabody Picture Vocabulary Test – Revised
PWRORA	Personal Responsibility and Work Opportunity Reconciliation Act
ORCE	Observational Record of the Caregiving Environment

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1

Introduction

The increased labor force participation of women during the post-World War II era is the main reason why most of the children in the United States are placed in childcare arrangements where the caregiver is someone other than their parents. For example, while in 1950 only 11.9% of the married mothers with children under 6 years old were in the labor force (Blau and Currie, 2006), in 2009 this number has increased to 61.6% (US Census Bureau, 2011). As a result, 12.5 million or 61% of children under the age of 5 were in some kind of regular childcare arrangement in 2011 (Laughlin, 2013).

The experiences of the child in day care settings come at a time when she develops skills that can have a lasting impact on later life outcomes. Indeed, Bernal and Keane (2011) find that, controlling for maternal characteristics, higher math and reading scores at ages 4-6 have a significant effect on completed schooling. Other studies such as Cunha and Heckman (2008) and Keane and Wolpin (2001) show that most of the skill endowment responsible for later labor market performance is already in place by the age of 16. Unfortunately, much less is known about the determinants of early skill formation and the potential of government policies to influence them.

The current study explores the effects of childcare characteristics, i.e., type, quantity and quality, on early cognitive attainment. Our emphasis is on features of labor income and childcare price changes which would maximize their beneficial effect on cognitive skills through the impact on household choices of childcare attributes. To that end, we estimate an empirical model which handles household childcare choices and production of cognitive skills in a unified framework. As Rosenzweig and Schultz (1982) point out in the context of child health, we must know two sets of parameters in order to be able to predict how changes in prices will affect child outcomes: (1) the marginal products of childcare inputs in the production function; and (2) the parents' substitution patterns across childcare characteristics described by the demand functions for those inputs. While in principle such a model is capable of generating a wide range of policy implications, in this paper we illustrate its potential by assessing the effect of wage and childcare prices changes on the cognitive attainment of children with married mothers.

More precisely, we look for insights related to the design of tax policies that are effective in stimulating cognitive development by addressing the following questions: (1) what wage rate and price changes can bring disproportionate gains in the cognitive attainment of children in low income families; (2) can changes in market variables be more effective in improving cognitive skills if they target the utilization of a particular type of paid care; (3) how does the conditioning of wage rate and price changes on paid childcare use and employment impact their effect on early cognitive development; and (4) does the timing of the change in a market variable with respect to the life cycle of the child matter for its effect on early cognitive attainment. It is worth emphasizing, though, that tax incentives are just one of the tools at the disposal of the government to affect early cognitive development. Others include publicly funded intervention programs like Head Start, regulations on childcare providers in terms of group sizes, regulations on child-to-staff ratios and caregiver's education, and state

funded pre-school programs. Our assessment of the effect of quality of non-relative care on the production of cognitive skills gives some idea of the potential impact of early intervention programs[1].

The major challenge faced by every study dealing the determinants of early childhood outcomes is the selection problem resulting from the correlation of type, quality and quantity of childcare with unobserved characteristics of parents and children. As a simple illustration of the problem[2], consider the following production function for cognitive attainment B_t at time t

$$B_t = \sum_{\tau=1}^{t} \boldsymbol{I_\tau}\boldsymbol{\beta_\tau^I} + \beta_t^\delta \delta_0 + \beta_t^\lambda \lambda_B + \epsilon_t^B, \tag{1.1}$$

where $\boldsymbol{I}_\tau$ are parental investments in children outcomes related to the home environment and the childcare setting at time τ, δ_0 is the inborn ability of the child, which is unobserved by the econometrician, λ_B is an unobservable characteristics of the mother, which affects her parenting skills, and ϵ_t^B is a measurement error. If the number of hours the child spends in paid center-based care $F_{\tau d}^p$ is one of those parental investment, we can represent the corresponding family decision rule as:

$$F_{\tau d}^p = F_d^p(\boldsymbol{W_\tau}, \delta_0, \lambda_{F_d^p}). \tag{1.2}$$

Here $\boldsymbol{W}_\tau$ denotes the relevant market variables and observed household characteristics, while $\lambda_{F_d^p}$ is some unobserved quality of the mother that has influence on this particular choice. The source of endogeneity coming from $\text{Cov}\,(\lambda_B, \lambda_{F_d^p}) \neq 0$ is a case of an omitted input λ_B. It can reflect a scenario in which mothers, who are more able to create a stimulating home environment for the child, also work more hours and prefer day care centers. On the other hand, the selection problem associated with δ_0

[1] However, a comparison of the effectiveness of different government measures is beyond the scope of this study.

[2] Note that our notation for the actual model considered in this study is not the same.

is present even if there are no missing inputs (Todd and Wolpin, 2003) – household choices are likely to be affected by information related to the abilities of the child which only family members possess.

Additional selection issues related to household childcare decisions arise even if the production function of cognitive attainment was not estimated at all. Wages and childcare prices are observed only for mothers who are employed and using the particular type of paid care arrangement respectively. Furthermore, since the values of childcare attributes such as quantity and quality are likely to depend on the mother's employment and type of non-maternal care, we should account for the fact that women who work and/or use paid care arrangements might differ systematically from other mothers based on some unobservable characteristics.

We address all selection issues using a quasi-structural estimation approach similar to the one in Bernal and Keane (2010)[3]. This approach entails approximating the family decision rules for maternal employment, childcare modes and childcare attributes implied by a theoretical model of household choices and early cognitive development[4]. Those decision rules are in fact the choices between discrete states[5] defined by employment status and paid care mode use, and the demand functions for childcare characteristics and goods enriching the home environment[6] derived from the first-order conditions of the utility maximization problem as functions of the relevant state variables identified by the theoretical model[7]. They are estimated jointly with the cognitive outcomes of the child by introducing common unobservables in the disturbance terms of the equations.

[3] A comparative review of other methods dealing with selection in the context of early cognitive development is in chapter 2.

[4] Our theoretical model is described in chapter 3.

[5] The choice in this context is based on comparing the indirect utility functions associated with each state.

[6] Throughout this paper we will also refer to them as home goods.

[7] Such demand functions are behind equation (1.2).

The main appeal of the quasi-structural estimation approach in terms of the goals of this study is its ability to handle unobserved heterogeneity in a rich system of discrete and continuous choice equations. At the cost of putting aside the effect of the forward-looking behavior of the households and assuming a particular distribution of the unobserved factors[8], this approach provides a way to deal with selection in a way which is consistent with theoretical considerations. We adapt the version of the method in Bernal and Keane (2010) to include multiple measures of the latent cognitive skills and allow for imputation of wages for mothers, who do not work, and childcare prices for mothers, who have not used that type of paid care.

Our empirical approach can work only if there are exclusion restrictions for the decision rules, i.e., variables which affect household choices but not cognitive outcomes directly. For that purpose we use the variation in childcare prices, exogenous to the characteristics of the household, which is identified by the geographic market associated with the family's place of residence. Such a strategy is adequate in our case because of the sampling procedures used or the dataset analyzed in this paper, i.e., the National Institute of Child Health and Development Study of Early Child Care and Youth Development (NICHD SECCYD). At the time of the child birth, mothers were recruited from hospitals in the vicinity of 10 collection sites which we use to define 10 different markets[9].

The NICHD SECCYD is uniquely suited to the goals of this study since there are very few datasets that include data on wages, prices, childcare choices, employment history, measures of the home environment, household characteristics, measures of maternal attitudes and preferences, and cognitive outcomes at the same time[10]. Its

[8] The impact of those distributional assumptions can be mitigated if we use discrete factors or mixture of normal distributions.

[9] Detailed information on the sampling procedures and the effect of geographic location on prices is included in chapter 4.

[10] Another dataset which includes data of consistent quality for those variables is the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K).

other main advantage is the survey's measure for quality of day care which focuses only on the child involved in the study, instead of reflecting the average experience of children in the same arrangement. This measure is comparable across all primary non-maternal arrangements and captures the specifics of the child-caregiver interactions. Unfortunately, this measure was not observed if the caregiver refused the live assessment or the child spends less than 10 hours a week in a childcare arrangement. In contrast to the majority of the literature exploring the NICHD SECCYD dataset[11], we address this issue explicitly by imputing those missing quality values inside the maximum likelihood estimation routine based on the parameters of the demand function associated with them.

To our knowledge there are no other studies which deal with the impact of price and wage change characteristics on the formation of early cognitive skills. The main reasons for that are the prevailing interest in the effect of those changes on outcomes such as maternal labor supply (e.g., Tekin (2007)), the limited choice of datasets which contain the necessary variables, and the empirical challenges related to considering a large number of correlated continuous and discrete outcomes and choices. While there are studies like Bernal and Keane (2010) which use a common estimation framework for parental choices and cognitive attainment, the type and quality of non-maternal care are not taken into account. The literature related to the demand for childcare attributes (e.g., Blau and Hagy (1998)) devotes more attention to characteristics of non-maternal care other than its use and intensity, but does not assess their importance for the formation of early cognitive skills. In terms of our contribution to the large number of studies analyzing the NICHD SECCYD dataset, it should be noted that we introduce a new method for selection bias correction. Furthermore, we allow the marginal products of quality and quantity of childcare to vary across different combinations of those inputs, which previous studies have largely ignored.

[11] The two exceptions are reviewed in chapter 2.

The remainder of the paper is organized as follows. Chapter 2 provides a comparative overview of the related literature focusing on methods for handling selection issues in the estimation of the production function for cognitive attainment, as well as approaches for estimating the demand functions for childcare attributes. Chapter 3 presents the theoretical model, the quasi-structural estimation approach associated with it, and our strategies for handling outcomes with multiple measures and inputing missing variables such as wages, prices and quality of day care. Chapter 4 describes the NICHD SECCYD dataset, the variable construction method relying on matching data from different assessment points in the study, the extent of the missing quality problem and preliminary findings regarding the ability of the geographic market identifiers to explain variation in childcare prices. Chapter 5 presents our estimates of the discrete choice equations and the demand functions for childcare characteristics which provide insights into parents' substitution patterns among childcare attributes. Chapter 6 assesses the properties of the production function for cognitive attainment with a focus on the variation of the marginal products of the inputs with respect to their levels and timing of introduction relative to the child's birth. Chapter 7 evaluates the effects of several wage rate and price changes and compares the relative differences between them in order to answer the four main questions we posed above. Chapter 8 summarizes our findings and suggests extensions of the current work.

2

Overview of Related Work

There is a long line of studies in the developmental psychology literature focusing on the effects of the increase in the labor supply of mothers on children's outcomes. They are motivated by the concern that mother's care might possess unique features which, as stated in Coleman (1988), could result in maternal employment weakening the parent-child relationship and undermining its future effectiveness in preventing negative outcomes. If such a concept holds true, any form of care different from the one provided by the mother would be detrimental to the child's development. The estimation approaches of these studies failed to account for the fact that working and non-working mothers might also differ in unmeasured traits affecting the child's early development. A major problem with such empirical models is that finding a positive effect of maternal labor supply on early cognitive ability could be a reflection of a scenario in which women, who are more likely to work, are also able to provide a more enriching home environment. Bernal and Keane (2011) and Ruhm (2004) summarize the inconclusive results from this literature, noting that roughly a third of these studies find positive effects of employment (e.g.,Parcel and Menaghan (1994)), another third find negative effects (e.g.,Mott (1991)), and the remaining report results

which differ with the timing of work and the group of interest (e.g., Baydar and Brooks-Gunn (1991)).

More recent studies have used various non-experimental statistical methods to mitigate the problem of selection bias in estimating child development production functions. Blau and Grossberg (1992) utilize an instrumental variable approach by assuming that prior work experience of the mother affects post-birth labor supply but not children's outcomes directly. However, such an assumption might be problematic if prior experience has a positive effect on the ability to afford a more stimulating home environment or if mothers, who are more committed to the labor market, also have a different parenting style. In general, finding exclusions restrictions or variables which affect maternal labor supply or childcare decisions, but not children's development poses a very difficult task in this literature. Currie and Thomas (1995) face similar issues when analyzing the effects of Head Start and eventually drop the instrumental variable approach. Bernal and Keane (2011) make a substantial contribution in this area by using the 1996 Welfare Reform and earlier state level policies to construct a comprehensive set of variables which they use together with local demand conditions as instruments. However, recognizing that those factors affect predominantly the decisions of single mothers, they exclude married women from their analysis.

Another common approach dealing with selection in the literature is the use of siblings effects adopted in James-Burdumy (2005), Blau (1999a), and Chase-Lansdale et al. (2003). The potential pitfall for this strategy is that it does not account for the fact that parental investments might be specific to the endowment of the particular child in the household. Duncan and NICHD (2003) use child fixed effects and value-added models but those approaches are sensitive to the possibility that investments might respond to lagged outcomes of the child. The above study is also among those who assess the impact of the mode and quality of non-maternal care. According to its findings, specifications of the skill formation equation which try to decrease

the role of selection reduce significantly the influence of quality of day care on child development. One standard deviation increase in the quality score for children above the age of 3 years leads to a 0.04 to 0.08 standard deviations rise in cognitive scores when they are 5 years old. Center-based care in the third and fourth year was also found to be a predictor of better cognitive outcomes.

Among the other few serious attempts to control for selection issues in the context of quality of day care arrangements are the use of generalized propensity score in Dearing et al. (2009), and the family fixed effects in Blau (1999a). The last paper uses data from the National Longitudinal Study of Youth (NLSY) and finds insignificant effects of early childcare characteristics such as training and staff-to-child ratios and small positive effects of smaller group sizes in arrangements taking place during the second three years of life on cognitive outcomes. Most studies on this subject find that quality matters more for children from impoverished background – e.g., Desai et al. (1989), Caughy et al. (1994), and McCartney et al. (2007). However, their methodology does not shed light into the properties of the production function or the specifics of the selection process responsible for that observation. Furthermore, failing to account for endogeneity in those studies undermines the policy implications of such findings. Most of them do not develop a framework that distinguishes between the effects of the variation of childcare modes and the variation of quality of care within modes.

There have also been several structural studies on the subject which estimate in a dynamic decision framework both the parameters associated with the utility function of the households and those capturing the properties of the production function for children's cognitive skills. Bernal (2008) estimated a model of labor market decisions of married women and test scores of their children. Liu et al. (2010) looked at the effect of both maternal employment and migration, while Tartari (2006) analyzed the impact of divorce on child development. A point worth emphasizing here is that such

models relying on full solution/full information maximum likelihood approach also require exclusion restrictions for identifying the the marginal products of the inputs in their production functions, i.e., variables which affect only household decisions but not outcomes directly. For example, Bernal (2008) assumes that temporary shocks to household incomes do not affect investment in children and therefore do not enter the estimated specification of cognitive skill formation.

Restrictions on the covariance structure of the estimated equations is another strategy used in the literature to address selection issues. Blau (1999b) employs a random-effect approach for estimating the effect of income on children's outcomes. He argues that the reduced-form equations resulting from the solution to the structural model imply that there are no variables affecting income but not cognitive development directly. Therefore, he estimates equations for income and cognitive scores by including a discrete factor with equation-specific loadings in both of them. Cunha and Heckman (2008) use a theoretical framework to introduce covariance restrictions. Their strategy is based on the assumption that the variables describing different aspects of the home environment are in fact all measures of the same latent factor representing parental investments and, similarly, all test scores and behavioral indexes are measures of latent cognitive and non-cognitive skills respectively.

The adopted empirical strategy in our study is based on the quasi-structural approach outlined in Bernal and Keane (2010). As we have already mentioned in chapter 1, this method entails approximating the control variables by linear functions of the relevant household and local market characteristics in the information set of the mother, and estimating them jointly with cognitive development equations and other processes affecting decisions and outcomes. We provide more details on its advantages and disadvantages in section 3.2.2. While the methodological insights from Bernal and Keane (2010) guide the general empirical strategy employed here, our paper differs from that study in two major aspects. First, in addition to the quantity of childcare,

we also consider its quality and type, i.e., paid versus free care and center-based versus home care. The introduction of a richer choice set exploits even further the benefits of the quasi-structural approach, which provides a computationally inexpensive way to include additional decision rules in a theoretically consistent manner. Second, our empirical model allows the assessment of price and wage changes on cognitive skills by including those market variables explicitly in the decision rules for employment and paid care modes, as well as in the demand functions for childcare characteristics. Wages and childcare prices for mothers, who are not working or do not use that type of care, are imputed inside the main estimation routine, using the parameters associated with the specified processes for those variables in the model. This procedure is possible in our case because unlike the National Longitudinal Survey of Youth used in Bernal and Keane (2010), NICHD SECCYD contains data on childcare prices at all major assessment points. We also assume that our separate measures of the physical and psychosocial dimensions of the home environment, based on the richer version of the HOME index in NICHD SECCYD, are able to capture the effect of the home goods on cognitive skills. Therefore, after including them in the empirical model, we are not restricted to evaluating policies that do not alter the decision rule for goods investment in children.

In terms of the substantive findings in Bernal and Keane (2010), their results suggest that childcare is detrimental to cognitive development and attribute that result mainly to arrangements in which the primary caregiver is the grandmother, although they do not control for mode and quality of childcare in their estimation model. The presented evidence also implies that non-maternal care has larger negative effects for older children which is at odds with previous literature on the subject.

The line of research developed in studies like Cunha and Heckman (2008) and Cunha et al. (2010) emphasizes the need to identify "sensitive" and "critical" periods in the human life-cycle in which some inputs are especially effective in the production

of skills. Recognizing the different impact of early and late childhood investments, it is argued that the equity-efficiency trade-off for policy interventions exists only for the latter because of the high returns for remedial investments in young disadvantaged children. Those studies adopt a value-added production function for the formation of skills where the endowment B_t at time t is determined by its level in the previous developmental period B_{t-1} and current parental investment $\boldsymbol{I_t}$:

$$B_t = \mu B_{t-1} + \boldsymbol{I_t}\boldsymbol{\beta_t^I} + \epsilon_t^B. \tag{2.1}$$

That is in contrast to the more general cumulative approach used in this study and presented in equation (1.1), according to which all past inputs enter the production process directly and their effect is allowed to vary with respect to the period of their introduction in the life of the child. While we do not estimate the parameter μ assessing the self-productivity of skills, i.e., if higher stocks of skills in one period create higher stocks in the next period, including inputs from all developmental periods after the child's birth in our specification also allows us to compare the relative importance of those periods for cognitive attainment. Our evaluation of wage and price changes on the childcare inputs and cognitive outcomes adds another dimension to the analysis of "sensitive" and "critical" periods by addressing the question if certain tax policies are capable of exploiting them to facilitate the development of early cognitive skills. Furthermore, while Cunha et al. (2010) consider only parental investments in children, we concentrate on the impact of the children's experiences in childcare without ignoring the determinants of the home environment and its effect on cognitive attainment.

While we already discussed the advantages of the NICHD SECCYD dataset in terms of the goals of the paper, it should also be noted that it is a non-experimental study. Todd and Wolpin (2003) argue that experimental and non-experimental empirical studies of the determinants of achievement outcomes estimate different effects.

Experimental studies with randomized assignment of at least some of the inputs, such as the Early Training Project, the Carolina Abecedarian Project, the Perry Pre-School Project, and the Milwaukee Project[1], are able to capture the total policy effect of an exogenous change in those inputs. On the other hand, non-experimental studies based on observational data and a model of parental choices of inputs, are better suited to identify the parameters of the production function.

There is a considerable amount of previous work utilizing the NICHD SECCYD dataset. Its findings suggest that the effect of different attributes of care depends on the type of outcome analyzed. In terms of quality of non-maternal care, NICHD Early Child Care Research Network (1998) and NICHD Early Child Care Research Network (2000) arrive at the conclusion that children in higher quality care had somewhat better language and cognitive development during the first 54 months (4.5 years) of life. They also had somewhat better social development, i.e., were more cooperative. At the same time, children with higher quantity of non-maternal care (more hours) had no different cognitive or language skills (NICHD Early Child Care Research Network, 2000), but had more behavioral problems in care and kindergarten than did children with lower quantity (NICHD Early Child Care Research Network, 2000). In terms of mode of childcare, children who attended childcare centers had better cognitive and language development (NICHD Early Child Care Research Network, 2002), but also were recorded as having more behavioral problems in care and kindergarten (NICHD Early Child Care Research Network, 2004) than did children with less center-based care. In addition, studies consistently found greater relative importance of family features, i.e., whether home environment was stimulating, mother-child interactions, etc., in a child's development compared to features of non-maternal child care arrangements. For example, better mother-child interactions were associated with better cognitive and social outcomes for children by age 54 months (Jaeger,

[1] See Blau and Currie (2006) for a brief summary of the results.

1999). Finally, while young children in exclusive maternal care did not have cognitive and social outcomes different from those those who experienced non-maternal care (NICHD Early Child Care Research Network, 2006), high levels of maternal work are associated with lower levels of a child's cognitive development (Brooks-Gunn et al., 2002).

The above findings represent associations between child care, family factors and child outcomes, i.e., they need not be causal. These facts come from empirical models which do not account for the selection of children into childcare arrangements based on unobservable characteristics of the household. As NICHD Early Child Care Research Network (2006) notes, the researchers of NICHD SECCYD "did not assign children to different kinds of child care, nor did they determine how early in life children would enter child care or for how many hours each week. As a result, the study cannot reveal whether child care features are the direct causes of individual differences among childrens health, cognitive, or social outcomes." (p. 7).

Blau and Currie (2006) provide an extensive review of the studies focused on the effect of childcare price on female labor supply. Due to the nature of existing datasets and the strong interest of economists in female labor supply per se, most studies dealing with childcare choices have focused on the employment decision of the mother and use a generic non-maternal childcare option. Aside from the fact that to our knowledge there is no prior work estimating jointly complex childcare decisions and early cognitive outcomes, very few studies account even for free relative care (e.g., Ribar (1995)). As a result, such empirical models estimate only a labor supply function for the mother and demand functions for a very limited set of childcare attributes. That proves problematic in the light of the observation in Blau (2003) that omission of the free care alternative in the estimated model for childcare decisions makes obtaining consistent estimates of the employment equation impossible. Even fewer studies handle the choice between modes of care such as day care centers and family day

care homes[2] and the demand for quality attributes of childcare. Modeling the choice between day care centers and paid home settings becomes necessary if preferences guiding parents to choose one mode or the other also have an impact on the cognitive development of the child. As Galinsky et al. (1994) observe, parents utilizing family childcare value close supervision of their child's safety and the warmth and individual attention of the caregiver. On the other hand, those households choosing day care centers might favor a more stimulating physical environment and more extensive educational activities (Kryzer et al., 2007). Such attitudes are likely to be correlated with the parenting styles of the mothers and therefore excluding this aspect of parental choice in studies like Bernal (2008) might be a source of selection bias similar to the one discussed above.

Blau and Currie (2006) also summarize the methodological insights for handling wages and childcare prices in the cases when those variables are not observed because the mother is not employed or does not use paid care respectively. Since prices and wages reported by the mothers reflect not only exogenous market characteristics, but also the preferences of the household, imputing the "missing" values requires more than using the fitted values from a simple regression of the observed prices and wages on household characteristics and variables related to the human capital of the mother. The main approach utilized in the literature involves predicting the missing values after correction for selection into employment and childcare following Maddala (1986) and Tunali (1986). However, Blau and Currie (2006) argue that there are no theoretically justifiable restrictions for the first stage of this selection correction procedure in the case of childcare prices and suggest assumptions on the covariance structure as the only way to deal with selectivity when working with data based on consumer reports. In his analysis of the effect of subsidies on employment of single mothers Tekin (2007) takes advantage of the assumption that geographic markets

[2] Currie and Hotz (2004) is one of the exceptions here.

affect prices and wages but not household decisions directly. This is the empirical strategy used in our paper as well.

The findings of the vast literature analyzing the elasticity of employment with respect to the price of childcare are described in detail in Blau (2003), Chaplin et al. (1999) and Anderson and Levine (2002). Reported results vary substantially in magnitude due to the differences of data sources and empirical specification. Some of the major factors determining the estimated price sensitivity proved to be the marital status of the women and the use of consumer expenditure data and a multinomial choice setting in the studies. The childcare literature also focuses on the price and income elasticity of paid childcare quality and the sensitivity of the latter to household characteristics. Blau and Hagy (1998) estimate a joint model of labor supply and demand for childcare attributes such as group size and staff-to-children ratio. They use a hedonic price model similar to the one developed by Hagy (1998) and conclude that a decrease in the price of formal care leads to substitution toward that mode and an increase in the amount of hours for which households utilize it. However, demand for quality does not seem to respond to reduction in prices and that has important implications in terms of designing policies targeting the use of childcare arrangements favoring child development. From methodological point a view their estimation setup shows how the demand for quality of care can be added to a model of mode choice. Blau and Hagy (1998) estimate jointly equations for all control variables using the same household characteristics and market conditions as right-hand-side variables and including a common discrete factor in the disturbance terms.

It is important to recognize that cognitive development of the child is not the only consideration of the parents when they are choosing childcare arrangements. Waite et al. (1991), Lehrer (1989) and NICHD Early Child Care Research Network (1997) point out that factors such as presence of other siblings, maternal beliefs about employment, age of the child, reliability of the arrangement, and the ability

of the children to experience environment resembling a home cannot be ignored. Those considerations together with the fact that not all markets provide the type of childcare characteristics preferred by the particular household support the view expressed in Early and Burchinal (2001) that childcare arrangement might have an effect on cognitive development of children separate from the family characteristics determining them.

NICHD Early Child Care Research Network (1997) discusses another issue of significance for the current analysis of the effect of childcare inputs – access to quality for different income group. Similarly to Phillips et al. (1994), they find a curvilinear relationship between quality of care and parental income where children from middle-income families seem to receive the worst care. The obvious reason for that seem to be government support programs for families in difficult financial situation. That could potentially be another explanation of the evidence cited above that formal care seems to be reducing cognitive inequality. Other studies such as Cost, Quality and Child Outcomes Study Team (1995), however, show that low-income parents are more likely to select low quality centers.

For young children their experiences in an environment not fully controlled by their parents is related to various attributes of childcare. While, for example, defining quantity of childcare in terms of weekly hours is rather intuitive, quality can be characterized by two different dimensions which relation to children's outcomes is different. The "process" dimension of quality reflects the nature and the frequency of the interaction between the caregiver and the child, while the "structural" component refers to the more easily observed characteristics of the childcare arrangements such as group size, provider training, safety standards, etc. Although structural components of care are supposed to produce high "process" quality, reviews of the literature in Love et al. (1996) and Lamb and Ahnert (2007) show that measures of quality capturing the caregiver's responsiveness and attentiveness are much more frequently

associated with better cognitive outcomes than indicators such as teacher education.

We conclude our review of the related literature with one of the first studies showing the need for examining jointly the production function of child outcomes and the determinants of the demand for its inputs – Rosenzweig and Schultz (1982). They use a model of child health production in a utility maximizing framework, which implications for the childcare problem can be illustrated by adopting a simple technological process for the formation of cognitive skill B that involves just one period[3], two inputs – hours of paid center-based care F_d^p and hours of paid home care F_h^{p}[4], and the initial ability δ_0:

$$B = B\left(F_d^p, F_h^p, \delta_0\right) \tag{2.2}$$

One can derive the reduced-form demand functions for hours of work H_m, hours of paid center-based care F_d^p and hours of paid home care F_h^{f}[5] related to a mother with a set of characteristics $\tilde{\boldsymbol{W}}$[6], her wage rate w, the hourly price of center-based care p_d and the hourly price of home care p_h in the following way

$$Z = Z\left(p_d, p_h, w, \tilde{\boldsymbol{W}}, \delta_0\right), \tag{2.3}$$

for $Z = F_d^p, F_h^p, H_m$. Equations (2.2) and (2.3) and the fact that δ_0 does not depend on the wage or the prices allow us to link the changes in the child's outcome to the change in prices and wages in the following way:

$$\frac{\mathrm{d}B}{\mathrm{d}p_c} = \frac{\partial B}{\partial F_d^p} \times \frac{\mathrm{d}F_d^p}{\mathrm{d}p_c} + \frac{\partial B}{\partial F_h^p} \times \frac{\mathrm{d}F_h^p}{\mathrm{d}p_c}, \tag{2.4}$$

for $p_c = p_d, p_h, w$. Rosenzweig and Schultz (1982) use (2.4) to emphasize that in order to predict how changes in prices will affect child's outcomes we must know

[3] Consequently, time subscripts are dropped.

[4] This category includes family day care, babysitters and nannies.

[5] We explain this strategy in detail in chapter 3.

[6] This set includes their income as well.

two things: (1) all marginal products of the inputs in the production function which are affected by prices, and (2) parents' substitution patterns between any of those inputs, as well as any good which price affects them. Therefore, if in our case we want to know the effect of a decrease in the price of center-based care on cognitive skills, it is not enough to know how such a change would affect the demand for hours in that arrangement, or even how the associated change in that input would affect the production of skills. The model presented in the next chapter involves a more complex choice set with numerous periods and types of inputs, but the main point in Rosenzweig and Schultz (1982) about what information we need to assess price changes remains.

3

Theoretical Issues and Estimation Model

3.1 Theoretical framework

We make several assumptions in order to fit the specifics of the data set and and develop a feasible corresponding estimation framework. The household unit consists of a mother, a partner or a husband (if present), and the child. All decisions regarding the distribution of resources, including her own time, are made by the mother. Let $t = 0, \ldots, T$ denote a period in which the household is observed, where $t = 0$ and $t = T$ stand for the time of child birth and the age for enrollment in kindergarten respectively. In our setup mothers are not limited to choosing only between maternal care and an all-encompassing childcare option. They can pick for their child a home environment or a day care center facility with a more formal syllabus. Arrangements can also be paid or free, where the latter ones are usually provided by relatives.

The larger choice set also ensures that the model takes into account the fact that households choose a day care mode based not only on the developmental advantages it provides but also on other attributes such as safety standards, convenience, flexible hours, affiliation with preferred institution, ability to supervise the care giving environment, and keeping siblings together. Different types of childcare are also

characterized with different price schedules and state regulations. Each period the mother has to make discrete choices regarding her employment status (work or staying at home) and the use and mode of paid childcare options (paid day care center, paid home care, or no paid care). Let J_t denote a categorical variable that can take integer values $1, ..., J^*$, where each of those values represents a distinct combination of employment status and use of a paid care mode. In our case $J^* = 6$ and, for instance, $J_t = 1$ represents a state where the mother works and uses a paid day care center[1]. A full list of the states in our current setup is given in table 3.1.

Although the discrete choice part of the model differentiates only between paid care modes, our setup allows mothers to use free home care in each of the six states and free center-based care in states where a paid day care center is not utilized[2]. Therefore, mothers can use free and paid childcare simultaneously, which seems to be fairly common in real life situations and in the NICHD SECCYD data set in particular. It should be noted that in the current setup childcare provided by the father is considered free home care[3].

In this model the paid home care mode includes both family day care homes and babysitters or nannies in the home of the child. Although those two arrangements differ in attributes such as adult-to-child ratio and their price schedules, they both

[1] Richer models also differentiate between part-time and full-time work. Since we are interested in the hours of day care used and not in the labor supply per se, the main advantage of including part-time work decisions in this case would be allowing the wage rate to differ across the working states. However, that would considerably increase the number of possible states and create a problem for a data set like NICHD SECCYD which does not contain a large number of individuals. Therefore, we follow studies like Hagy (1998) and Blau and Hagy (1998), which do not model part-time work choices.

[2] The last restriction comes from the structure of the data which makes it impossible to identify simultaneous free and paid day care center utilization in all periods. However, unless the observed period is too long, it seems unlikely that many households use such arrangements concurrently.

[3] An alternative to that assumption is to consider paternal time input and parenting quality identical to those provided by the mother and thus distinguish between parental and non-parental care. We can also have paternal care as a separate mode, although, as in the case with part-time working decisions, that imposes higher demands on the data. Nevertheless, that could be useful if one wishes to identify separate effects of different kinds of free care.

take place in a home environment. Furthermore, the model uses the "process" dimension of childcare quality[4] which makes its measurement consistent across modes and at the same time allows differences across arrangements within the same mode. Since in the context of paid childcare we are interested predominantly in the effect of day care centers versus any other type of paid care, using an aggregate paid home care category is not at odds with the goal of the study.

Subscripts m, d and h are used for maternal care, day care center, and home care respectively, while the superscripts p and f stand for paid and free care arrangements in the notation for childcare attributes. The mother's utility depends on consumption goods G_t, her own leisure L_{tm}, the cost of free home care S^f_{th}, the cost of finding an appropriate paid care arrangement S^p_{tc} with $c = d, h$, the non-quality attributes of paid care $\boldsymbol{A^p_t}$, and the level of the child's cognitive abilities B_t:

$$U_t(G_t, L_{tm}, S^f_{th}, S^p_{td}, S^p_{th}, \boldsymbol{A^p_t}, J_t, J_{t-1}, B_t; \boldsymbol{X^U_t}, \lambda^U_t), \tag{3.1}$$

where $\boldsymbol{X^U_t}$ combines constant and time-varying exogenous variables and λ^U_t stands for unobserved preferences. The cost of free home care may vary across individuals due to reasons like, for example, the presence of older children or grandparents in the same home. The current state J_t, as well as the previously chosen state J_{t-1}, also have an impact on utility, where the former shows preferences toward a specific combination of employment status and paid day care mode, while the latter represents a pattern of habit formation.

In addition to the choice between discrete states, the mother also chooses the hours (F^p_{td} and F^p_{th}) and quality (Q^p_{td} and Q^p_{th}) of paid childcare, as well as her labor supply H_{tm} and the level of investment in a home environment that stimulates child development E_t (books, learning toys, etc.). She makes a decision about the amount of free day care center utilization F^f_{td} in case she forgoes using paid day care centers,

[4] As we have already discussed in chapter 2, "process" quality results from interactions between the child and the caregiver (Pater and Filius, 2002).

and hours of free home care F_{th}^f no matter what her choice of discrete state was. The employment status of the husband, his labor income, fertility decisions, as well as the presence of other members in household, such as siblings or grandparents, are considered exogenous in this framework, but included as factors affecting the budget constraint and the resources available for finding relative care and providing an enriching home environment[5].

The budget constraint, which the household faces each period, incorporates the expenditure on good consumption G_t , expenditure on home goods stimulating cognitive development $\tilde{E}_t$[6], and paid day care, as well as income from the mother's employment and non-labor income Y_t:

$$G_t + p_{td}F_{td} + p_{th}F_{th} + \tilde{E}_t = w_t H_{tm} + \underbrace{M_t Y_t^k + Y_t^o}_{Y_t}, \tag{3.2}$$

where M_t is the marital status of the mother (which includes cohabitation as well), Y_t^k is the income of the partner, and Y_o^t is income from other sources such as investments or alimony but excluding welfare or government assistance[7]. The wage rate is a function of the mother's human capital represented by her observable ($\boldsymbol{X_t^w}$) and unobservable (λ^w) characteristics, as well as the geographic labor market g and a temporal shock ξ_t^w:

$$w_t = w(\boldsymbol{X_t^w}, g, \lambda^w) + \xi_t^w \tag{3.3}$$

The hourly price of care in mode $c = d, h$ is partly determined by variables such as quality Q_{tc}^p and non-quality attributes of care $\boldsymbol{A_{tc}^p}$, which are chosen by the household and therefore endogenous to the model. For that reason we distinguish between two

[5] Exogeneity of the family structure is a strong, but frequently used assumption in the childcare literature dealing with married and single women together – see Fronstin and Wissoker (1994).

[6] In this model the unit price for home goods is assumed to be the same for each household and therefore $\tilde{E}_t = \nu E_t$

[7] It is possible to include an additional choice for the mother in this framework, i.e., welfare participation.

components of the price in our hedonic specification of the price schedule for mode c:

$$p_{tc} = \widetilde{p_{tc}}(g, \boldsymbol{StF_t^g}) + p_c'(\boldsymbol{A_{tc}^p}, Q_{tc}^p) + \xi_t^{p_c}, \tag{3.4}$$

where g denotes the geographic market, $\boldsymbol{StF_t^g}$ are state-wide government policies and ξ_t^{pc} is a price shock. Any price effects of interest results from introducing a change in $\widetilde{p_{tc}}$ which is independent of any chosen attributes[8].

We include regulations of day care centers and family homes, as well as state expenditures on items related to childcare assistance, to provide plausible exclusion restrictions for the decision rules in addition to the geographic market identifiers. Those government policies $\boldsymbol{StF_t^g}$ together with a shock $\xi_t^{S_c^p}$ are also responsible for the ease with which a desired paid day care arrangement is found:

$$S_{tc}^p = S_c^p(\boldsymbol{StF_t^g}) + \xi_t^{S_c^p}, \text{ where } c = d, h. \tag{3.5}$$

To complete the setup of the choice framework, we have to specify the time constraints for the mother and for the child ensuring that at all times there is someone taking care of the child:

$$L_{tm} + H_{tm} + F_{tm} = R \tag{3.6}$$

$$F_{td}^p + F_{th}^p + F_{td}^f + F_{th}^f + F_{tm} = R, \tag{3.7}$$

where R is the total time endowment for the period. Handling the allocation of the mother's time input between leisure and maternal care has proven difficult due to paucity of data on the matter (see Kimmel and Connely (2006) for more details). In the current setup the maternal time input which enters the production process for cognitive abilities is the aggregate time which the child spends with her mother.[9]

[8] The additive separability in $\widetilde{p_{tc}}$ from equation (3.4) follows specification in Hotz and Xiao (2011) and Blau and Hagy (1998).

[9] Under that assumption time spent with both parents together is also considered "maternal time input". As a consequence, time with the mother might mean something different for children of single and married women. However, this issue is difficult to resolve without detailed diary data for each time period, as it is the case with NICHD SECCYD.

We utilize a cumulative specification for the production function of cognitive skills which includes all inputs from the child's birth to the time when those skills are assessed:

$$B_t = B_t\left(\boldsymbol{I_1}, ..., \boldsymbol{I_t}, \delta_0, Q_m\right) + \xi_t^B. \tag{3.8}$$

The time-varying inputs in the production process are given by $\boldsymbol{I_\tau} \equiv [E_\tau \ \boldsymbol{F_\tau} \ \boldsymbol{Q_\tau}]$, where, as discussed above, E_τ are goods related to the physical environment of the child's home. Denoting by K_{tc}^k the indicator whether the mode of care c with payment status k is utilized allows us to specify the quality attributes of non-maternal care which affect the child's development:

$$\boldsymbol{Q_\tau} \equiv \left[K_{\tau d}^p Q_{\tau d}^p \ K_{\tau h}^p Q_{\tau h}^p \ K_{\tau d}^f Q_{\tau d}^f \ K_{\tau h}^f Q_{\tau h}^f\right]$$

We can similarly define the intensities of the exposure to non-maternal care:

$$\boldsymbol{F_\tau} \equiv \left[K_{\tau d}^p F_{\tau d}^p \ K_{\tau h}^p F_{\tau h}^p \ K_{\tau d}^f F_{\tau d}^f \ K_{\tau h}^f F_{\tau h}^f \ F_{\tau m}\right].$$

The disturbance term ξ_t^B combines a transitory shock to the child's skills and a measurement error specific to the test measuring them, while δ_0 denotes the innate ability of the child which is correlated, but not necessarily caused by the observable variables $\boldsymbol{X_B}$ and an unobservable component λ^B:

$$\delta_0 = \delta_0(\boldsymbol{X^B}, \lambda^B). \tag{3.9}$$

The parenting skill of the mother is given by Q_m and stays constant until the child's age of entry in kindergarten. It is determined by her characteristics $\boldsymbol{X^{Q_m}}$ at the time of birth and an unobservable factor λ^{Q_m} specific to her:

$$Q_m = Q_m\left(\boldsymbol{X^{Q_m}}, \lambda^{Q_m}\right) \tag{3.10}$$

As discussed above, the time-varying components of the home environment are captured by the purchased goods facilitating learning, E_τ. The quality of free home care,

which, as discussed above, in the vast majority of cases is relative care, is assumed to be related to the parenting qualities of the mother and some unobserved family characteristic $\lambda^{Q_h^f}$:

$$Q_{\tau h}^f = Q_h^f \left(Q_m, \lambda^{Q_h^f} \right). \tag{3.11}$$

Such a specification comes from the notion that similar family characteristics shape the parenting approach of the mother and the caregivers from her family. Furthermore, if the mother chooses a relative care arrangement, she is likely to shape that experience in a way which resembles her own parenting style.

Since a scenario in which the mother can choose between several free options of center-based care seems unlikely, in this model we also assume that she does not control the quality of free day care center Q_{td}^f, i.e., it is a characteristic of the geographic market g. Furthermore, the mother is unaware of the current level of Q_{td}^f when she is deciding whether to use this arrangement or not. Such an assumption can be justified on the basis that those free arrangements are usually age-specific and thus mothers might find it difficult to form beliefs about their quality in advance[10].

The specification of the production function of early child attainment in (3.8) allows the identification of periods in which the development of the child is more sensitive to childcare inputs and in that way we can capture more accurately the different impact exogenous shocks to the determinants of parental choices can have on the early cognitive outcomes depending on their timing with respect to the child's age. We already discussed in chapter 2 that the alternative added-value specification of the cognitive attainment process, in which current skills depend on their level in the

[10] The inability of the mother to predict quality in free center-based care ensures that geographic markets do not affect directly the household decisions, which is a necessary feature of the model in order to identify price effects, as discussed in section 3.2. The effect of this assumption, however, can be mitigated to a certain degree by the fact that some location-specific variables still enter the decision rules in the form of state-wide government policies. This is consistent with a story in which mothers form their beliefs about the level of free day care centers based on those publicly announced policies.

last period and the subsequent inputs, is actually a particular case of our cumulative specification. In addition, added-value formulations are likely to perform better when the cognitive measures are similar across periods and that is not the case with NICHD SECCYD early assessments.

Unlike previous studies (e.g., Duncan and NICHD (2003)), we do not assume that an additional hour of care has the same effect on the child's skills regardless of the quality of the arrangement and the intensity of the child's exposure to it. Instead, we allow the marginal products of inputs to depend on the level of inputs associated with the same mode of care. The precise empirical specification is discussed in section 3.2.3.

As we are going to discuss in section 3.2.2, our quasi-structural estimation approach does not require assumptions on what the mother knows about the cognitive development process, her parenting skill, or the innate ability of the child. Therefore, our results are consistent with various sets of assumptions in this respect which include assuming that the mother has full knowledge of the technological process and the inborn endowment or a scenario where the mother observe only a component of δ_0.

3.2 Emprical strategy

3.2.1 Main considerations

In this section we discuss the issues we need to confront when estimating an empirical model with the following features: (1) selection and endogeneity problems related to childcare inputs, (2) missing quality attributes of paid care, and (3) missing wages and childcare prices for households who are not working or using paid care. The sources of selection bias in childcare attributes and the child's abilities have already been discussed at length in the previous chapter – parents are likely to selectively differ in their choices of quality and quantity of childcare arrangements and these differences may depend on factors not observed by the econometrician.

Missing quality measures is a problem specific to NICHD SECCYD dataset which we discuss in more detail in chapter 4. The quality of non-maternal care is assessed through the Observation Record of the Caregiving Environment (ORCE), which is a live observational instrument especially designed for this study to make the quality of all types of care comparable across arrangements. The child and the caregiver are observed and qualitative ratings are given based on the specific behaviors of the caregiver related to her sensitivity to the child's non-distress expressions and stimulation of cognitive development (NICHD Early Child Care Research Network, 2001). Whether an arrangement is eligible for observation, depends on several requirements should be fulfilled in terms of the amount of hours a week the child spends there, the nature of other arrangements the mother uses, and the number of weeks the child has already spent in this arrangement. In addition to that, some caregivers deny observers the opportunity to conduct their evaluation[11]. Studies like Duncan and NICHD (2003) tackle this problem by including a dummy variable for missing quality in the cognitive outcome equation. Here we model quality explicitly which allows us to substitute the relevant process directly into the cognitive ability function when an input is missing. However, for reasons which become apparent below, in estimation terms such an approach is more problematic when, as the more general theoretical model prescribes, the missing quality enters the discrete choice equations. To address that, we make certain simplifying assumptions on the preferences and the production process, so that current decisions do not depend on past inputs to the production of cognitive skills.

In the previous chapter we showed that the lack of childcare prices and wages for people who are not utilizing paid care and do not work respectively has been handled in the childcare literature by the use of a two-stage double selection correction

[11] More detailed information on the frequency of missing observation is provided in the next chapter.

method[12] which accounts for the fact that people who are observed using childcare and/or working might differ systematically from the other part of the population. In this approach prices and wages are imputed when necessary using the relevant definition of their expected value. In that way mothers are implicitly assumed to be reacting to different theoretical constructs for the wage and the prices depending on their choices[13]. We take a different approach and assume that regardless of their decisions, all mothers react to the expected value of their compensation which excludes the idiosyncratic shock but not the common unobservables in the wages actually observed[14]. Handling missing data inside the main estimation procedure allows us to take advantage of efficiency gains and treat individuals with and without missing observations of quality, wages, and prices in a consistent manner.

3.2.2 Quasi-structural approach with missing data modifications

We use a quasi-structural estimation framework – a term introduced by Bernal and Keane (2010), although a similar approach in which structural parameters associated with the production function for child outcomes are estimated jointly with the parameters of reduced-form demand functions is used in earlier studies such as Rosenzweig and Schultz (1982). Instead of estimating a full blown structural model, this approach entails approximating the rules for choosing the discrete state associated with the highest value of the indirect utility function, as well as the demand functions for childcare characteristics implied by the theoretical model described in section 3.1. Those household decisions are derived from the first-order conditions of the

[12] See also Blau and Currie (2006) for a review of those studies.

[13] An exception in that respect is Tekin (2007) who integrates out the missing idiosyncratic shocks in the wage and the prices when those variables are not observed. Although this approach is theoretically appealing, it is hard to adopt in the current framework where, in contrast to Tekin (2007), multiple time periods are modeled and the dimension of integration can get really high for people who never work or use paid care.

[14] Another way to state this assumption is that there is incomplete contracting, that is mothers and employers agree in advance only the expected value of the wage.

utility maximization problem as functions of the relevant state variables and estimated jointly with the outcome equations for quality of parenting and children's test scores, as well as the wage and childcare price processes. According to this method, all estimated equations are linked only through the common unobservable in their disturbance terms.

The advantages and disadvantages of this approach are discussed at length in Bernal and Keane (2010). In a multi-period setting with such a great variety of estimation equations, this framework highlights the identifying assumptions in the empirical specification and allows the theoretical model to determine in a straightforward way the exclusion restrictions in the resulting system of simultaneous equations. For example, as we are going to demonstrate below, wages, prices and government policies enter decision equations but not cognitive outcome equations directly, while geographic markets affect wages and prices but not parental choices.

The quasi-structural approach also explicitly models unobserved heterogeneity, which can be useful if one wants to attach a particular theoretical meaning to it or explore interactions between observed characteristics or inputs and unobserved factors. An additional advantage over another method for dealing with endogeneity – instrumental variables – is that estimating all equations together could produce substantial efficiency gains. The obvious major downside is that mis-specification of the joint distribution of the unobservables could result in inconsistent estimates. Nevertheless, using a discrete distribution for the common unobservable (see Mroz (1999)) or a mixture of normal distributions can mitigate this problem.

In contrast to the full solution/full information maximum likelihood approach, quasi-structural estimation does not require a full specification of what mothers know about the skill endowment of the child and the properties of the production function, or how they form their expectations about the processes and variables affecting their decisions such as government policies. Avoiding assumptions on how much parents

know about the production function of cognitive skills and the skill endowment of the child is a substantial advantage for the quasi-structural approach, since early development is associated with a great deal of uncertainty not only for econometricians, but for the parents as well. Furthermore, we can skip the estimation of decision rules for variables which are related to the childcare decisions but do not have an impact on the cognitive development or the home environment[15]. In our case such decisions are the non-quality related attributes of care, welfare participation, and the labor supply. The disadvantage of not modeling the perceived persistence of wage and price changes is restricting the ability to distinguish between policies with different effects on mothers' expectations.

The theoretical model from section 3.1 identifies the state variables $\widetilde{\boldsymbol{\Omega}}_{\boldsymbol{t}}$ at time t:

$$\widetilde{\boldsymbol{\Omega}}_{\boldsymbol{t}} \equiv \left\{ \overline{\boldsymbol{I}_{\boldsymbol{t-1}}}, \boldsymbol{X}_{\boldsymbol{t}}^{\boldsymbol{U}}, J_{t-1}, p_{td}, p_{th}, S_{th}^{f}, S_{td}^{p}, S_{th}^{p}, w_t, M_t, Y_t^k, Y_t^o, Q_m, Q_h^f, \delta_0, \lambda^U \right\}, \quad (3.12)$$

where $\overline{\boldsymbol{I}_{\boldsymbol{t-1}}} = \{\boldsymbol{I}_{\boldsymbol{1}}, ..., \boldsymbol{I}_{\boldsymbol{t-1}}\}$ is the set of all inputs to cognitive development used until period t.

We make the additional assumption that the cognitive development process defined in equation (3.8) is additively separable in the time-varying inputs, such that

$$B_t = \sum_{\tau=1}^{t} B_\tau' \left(\boldsymbol{I}_{\boldsymbol{\tau}}, \delta_0, Q_m \right) + \xi_t^B, \quad (3.13)$$

and mothers are aware of this separability. Furthermore, the utility in (3.1) is assumed to be linear in the cognitive ability of the child:

$$U_t(.) = \widetilde{U}_t(G_t, L_{tm}, S_{th}^f, S_{td}^p, S_{th}^p, \boldsymbol{A}_{\boldsymbol{t}}^{\boldsymbol{p}}, J_t, J_{t-1}; \boldsymbol{X}_{\boldsymbol{t}}^{\boldsymbol{U}}, \lambda_t^U) + \kappa B_t \quad (3.14)$$

Those assumptions ensure that the current decisions are not a function of past inputs to the production process which helps us solve the problem of missing paid care quality

[15] For that purpose we should further assume that such a step would not affect our ability to identify the correlation between the unobservables in the estimated equations.

by not having to integrate it out. Permanent components of the cognitive ability – both observable and unobservable – continue to impact decisions throughout all periods. It is worth noting that this feature of the estimation model can be obtained by different sets of assumptions regarding the utility function and the information set of the household. For example, the quasi-structural approach allows us to replace the real process of cognitive ability accumulation B_t with the the one perceived by the household $\hat{B}_t$ which may or may not coincide with the former. Additive separability in the perceived production function

$$\hat{B}_t = \widehat{B'}_t \left(\boldsymbol{I_t}, \delta_0, Q_m \right) + \xi_t^{\hat{B}}$$

and a much weaker notion of additive separability in the utility function than the one employed in (3.14)

$$\begin{aligned} U_t(.) = \overline{U}_t(G_t, L_{tm}, S_{th}^f, S_{td}^p, S_{th}^p, \boldsymbol{A_t^p}, J_t, J_{t-1}, \widehat{B'}_t, \xi_t^{\hat{B}}; \boldsymbol{X_t^U}, \lambda_t^U) \\ + \sum_{\tau=1}^{t-1} \bar{u}_\tau(\widehat{B'}_\tau) \end{aligned} \tag{3.15}$$

lead to the same implication regarding the set of variables affecting current choices. Under that specification, past inputs still affect the level of utility in the next periods but their contribution is fixed through time and possible future states and as a result they do not affect forthcoming decisions. One could interpret this assumption as a situation in which the outcome in the utility function $\hat{B}_t$ represents more than cognitive ability B_t – for instance, health and safety considerations or having the child in an environment which she enjoys. That would explain why a household would value in a different manner current and past childcare quality and quantity as equation (3.15) prescribes[16].

As our approach for handling missing wages suggests in section 3.2.1, we assume that when mothers make their decisions, they do not consider their actual realized

[16] An alternative scenario giving the desired feature of the decision rules is when mothers do not believe that past inputs contribute to future cognitive abilities due to the uncertainty regarding the

wage w_t, but instead its expected value w_t^*, which excludes temporary shocks uncorrelated with any other process or decision within the current framework:

$$w_t = w^*(\boldsymbol{X_t^w}, g, \lambda^w) + \xi_t^w = w_t^* + \xi_t^w \tag{3.16}$$

In a similar fashion, the hourly price of paid care which enters their decisions is the average quality-adjusted price p_{tc}^* for geographic market g as in Blau and Hagy (1998):

$$p_{tc}^* = \widetilde{p_{tc}}(g, \boldsymbol{StF_t^g}) + p_c'(\overline{\boldsymbol{A}}_{\boldsymbol{tc}}^{\boldsymbol{p(g)}}, \overline{Q}_{tc}^{p(g)}) \tag{3.17}$$

where $c = d, h$ and $\overline{\boldsymbol{A}}_{\boldsymbol{tc}}^{\boldsymbol{p(g)}}$ and $\overline{Q}_{tc}^{p(g)}$ are the averages of non-quality and quality attributes of the c^{th} mode of paid care in market g respectively, and $\boldsymbol{StF_t^{(g)}}$ are the statewide government policies affecting prices on this market. The term $p_c'(\overline{\boldsymbol{A}}_{\boldsymbol{tc}}^{\boldsymbol{p(g)}}, \overline{Q}_{tc}^{p(g)})$ is used so that p_{tc}^* has the same scale as p_{tc}. Under this specification, the mother reacts to the exogenous component of price associated with the geographic market in which she resides. Using prices from multiple markets is a crucial part of the identification strategy of input effects in our empirical approach. That feature not only allows us to recover various price elasticities, but the exogenous variation in prices also serves as an instrument which affects decisions and not cognitive outcomes directly. In this way we do not have to rely solely on the assumption that we have correctly specified the joint distribution of the unobservables in order to deal with the endogeneity issues in the production function for cognitive attainment.[17]

We also account for the fact that mothers might not know their exact level of

permanent effect of inputs on early child development:

$$\hat{B}_t = \widehat{B'}_t\,(\boldsymbol{I_t}, \delta_0, Q_m) + \xi_t^{\hat{B}}$$

That would also entail that mothers do not receive reliable signals about the contribution of past inputs to cognitive ability and take into consideration only the information they have on the initial endowment δ_0.

[17] An additional assumption for such a strategy to work is that household's decisions to move across geographic markets is not related to their childcare choices.

parenting skill, Q_m, or the quality of free home care, Q_h^f, but are aware of the characteristics determining them, i.e., $\boldsymbol{X^{Q_m}}$, λ^{Q_m} and $\lambda^{Q_h^f}$. Replacing Q_m, Q_h^f, S_{td}^p and S_{th}^p with their determinants from equations (3.10), (3.11) and (3.5) respectively, we can now define the modified state variables for the current setup[18]:

$$\boldsymbol{\Omega_t} \equiv \left\{\lambda^B, \boldsymbol{X^B}, \boldsymbol{X_t^U}, J_{t-1}, p_{td}^*, p_{th}^*, \boldsymbol{StF_t^g}, w_t^*, M_t, Y_t^k, Y_t^o, \boldsymbol{X^{Q_m}}, \lambda^{Q_m}, \lambda^{Q_h^f}, \lambda_t^U\right\} \tag{3.18}$$

3.2.3 Empirical implementation

In order to account for the unobserved heterogeneity and the fact that the prices of childcare p_{td}^* and p_{th}^* and the wage rate w_t^* are relevant to the budget set of the household only when certain combinations of employment status and childcare mode are chosen, it is instructive to divide the state variables in three groups:

$$\boldsymbol{\Omega_t} \equiv \{\boldsymbol{\Delta_t}, \boldsymbol{\Psi_{jt}}, \boldsymbol{\eta_t}\},$$

where $\boldsymbol{\Delta_t}$ includes all observable state variables apart from the market prices

$$\boldsymbol{\Delta_t} \equiv \left\{\boldsymbol{X^B}, \boldsymbol{X_t^U}, J_{t-1}, \boldsymbol{StF_t^g}, M_t, Y_t^k, Y_t^o, \boldsymbol{X^{Q_m}}\right\} \tag{3.19}$$

and $\boldsymbol{\eta_t}$ contains all unobservable characteristics. The market prices associated with a discrete state j comprise the remaining set of variables $\boldsymbol{\Psi_{jt}}$ which is described in details in table 3.1

Solving the model we can derive the the indirect utility function for state j in period t as a linear approximation of the relevant state variables:

$$V_{jt} = \boldsymbol{\Delta_t}\boldsymbol{\beta_\Delta^{V_j}} + \boldsymbol{\Psi_{jt}}\boldsymbol{\beta_{t\Psi}^{V_j}} + \eta_t^{V_j}, \tag{3.20}$$

where the unobservables are incorporated in $\eta_t^{V_j}$. In period t the household chooses state j^* if

$$V_{tj^*} = \max\left(V_{t1}, \ldots, V_{t6}\right) \tag{3.21}$$

[18] We also drop the cost of relative care S_{th}^f, which is captured by the fixed utility from the particular state j and some of the household characteristics in $\boldsymbol{X_t^U}$, such as the number of other adults or presence of siblings in the house. This is a common approach in the childcare literature (see Blau and Currie (2006)) when there is no data on variables such as having grandparents living nearby.

Table 3.1: Description of the Discrete States.

#	Description	Budget constraint	Market variables	Decisions
1	Work & Paid day care center	$G_t + p_{td}F_{td} + \tilde{E}_t = w_t H_{tm} + Y_t$	$\boldsymbol{\Psi_{1t}} \equiv \{p^*_{td}, w^*_t\}$	F^p_{td}, Q^p_{td}, E_t, F^f_{th}
2	Work & Paid home care	$G_t + p_{th}F_{th} + \tilde{E}_t = w_t H_{tm} + Y_t$	$\boldsymbol{\Psi_{2t}} \equiv \{p^*_{th}, w^*_t\}$	F^p_{th}, Q^p_{th}, E_t, F^f_{th}, F^f_{td}
3	Work & No paid care	$G_t + \tilde{E}_t = w_t H_{tm} + Y_t$	$\boldsymbol{\Psi_{3t}} \equiv \{w^*_t\}$	E_t, F^f_{th}, F^f_{td}
4	No work & Paid day care center	$G_t + p_{td}F_{td} + \tilde{E}_t = Y_t$	$\boldsymbol{\Psi_{4t}} \equiv \{p^*_{td}\}$	F^p_{td}, Q^p_{td}, E_t, F^f_{th}
5	No work & Paid home care	$G_t + p_{th}F_{th} + \tilde{E}_t = Y_t$	$\boldsymbol{\Psi_{5t}} \equiv \{p^*_{th}\}$	F^p_{th}, Q^p_{th}, E_t, F^f_{th}, F^f_{td}
6	No work & No paid care	$G_t + \tilde{E}_t = Y_t$	$\boldsymbol{\Psi_{6t}} \equiv \{\varnothing\}$	E_t, F^f_{th}, F^f_{td}

and the probability of this choice can expressed by:

$$\begin{aligned} Pr_t\left(J_t = j^*\right) &= Pr\left(V_{j^*t} > V_{jt}, \forall j \neq j^*\right) \\ &= Pr\left(\eta_t^{V_{j^*}} - \eta_t^{V_j} > \boldsymbol{\Delta_t}\left(\boldsymbol{\beta}_{\boldsymbol{\Delta}}^{\boldsymbol{V_{j^*}}} - \boldsymbol{\beta}_{\boldsymbol{\Delta}}^{\boldsymbol{V_j}}\right)\right. \\ &\quad \left. + \boldsymbol{\Psi_{j^*t}}\boldsymbol{\beta}_{\boldsymbol{t\Psi}}^{\boldsymbol{V_{j^*}}} - \boldsymbol{\Psi_{jt}}\boldsymbol{\beta}_{\boldsymbol{t\Psi}}^{\boldsymbol{V_j}}, \forall j \neq j^*\right) \end{aligned} \tag{3.22}$$

The decision rules for the continuous variables such as intensity of childcare use, quality attributes of non-maternal care and expenditure on development-enhancing environment are obtained in a similar way. Therefore, the mode-specific rule for the l-th outcome Z_{jlt} associated with mode j at time t is given by[19]:

$$Z_{jlt} = \boldsymbol{\Delta_t}\boldsymbol{\beta}_{\boldsymbol{\Delta}}^{\boldsymbol{Z_{jl}}} + \boldsymbol{\Psi_{jt}}\boldsymbol{\beta}_{\boldsymbol{t\Psi}}^{\boldsymbol{Z_{jl}}} + \eta_t^{Z_{jl}}. \tag{3.23}$$

While we restrict the coefficients in front of the non-market related observables to be constant through time [20], the effect of prices and wages on choices is allowed to vary across different time periods[21]. The list of state-specific attributes for each discrete

[19] A separate equation for maternal labor supply H_{tm} is not estimated since it does not enter the production function directly or through any of the inputs. The discrete working status decision, however, affect all childcare attributes and the expenditure on investment goods E_t, because the decision rules for all of those are specific to the discrete state. Alternatively, we can have the labor supply affecting the time-varying attributes of the home environment and estimate it as a separate outcome.

[20] Period-specific intercepts are, however, included in the specification.

[21] An exception here are the quality of paid care and hours of free day care where there are too few observations in the NICHD SECCYD dataset for those outcomes in certain periods.

choice is also given in table 3.1. Having a separate set of parameters for the same outcome in different states can work only if there are enough observations for this outcome in each of those states. That is a problem for the NICHD SECCYD dataset under the current specification since there are too few observations in states like "No work & Paid day care center". For that reason we allow only for different intercepts in the decision rules for a particular outcome in different states[22]. Substituting the decision rules for $\boldsymbol{A_{tc}^{p}}$ and Q_{tc}^{P} from (3.23) in equation (3.4), we obtain

$$p_{tc} = \boldsymbol{\Delta_t \beta_{\Delta}^{p_c}} + \boldsymbol{\tilde{g} \beta_{g}^{p_c}} + \eta_t^{p_c}, \tag{3.24}$$

where $c = d, h$, and since $\boldsymbol{\tilde{g}}$ is a set of geographic dummy variables indicating different markets, $\boldsymbol{\tilde{g}\beta_g^{p_c}}$ is the component of the price independent of the attributes chosen. In this way we have an estimation equation for the observed price which does not need the values of attributes of paid care that affect prices but are not present in the data. Equation (3.24) brings up a point made by Blau and Currie (2006), that is, since prices are affected by the attributes of care which are chosen by the household, no characteristic of the household can serve as an exclusion restriction for the price equations. Therefore, a plausible instrument that remains is the geographic market in which the mother looks for paid care.

The estimated process determining the observed wage is a linear version of (3.3)

$$w_t = \boldsymbol{X_t^w \beta^w} + \eta_t^w. \tag{3.25}$$

The empirical specifications for the quality of free day Q_{td}^{f} and parenting Q_m also follow closely the theoretical considerations in section 3.1:

$$Q_{td}^{f} = \boldsymbol{\tilde{g} \beta_g^{Q_d^f}} + \eta_t^{Q_{fd}} \tag{3.26}$$

$$Q_m = \boldsymbol{X^{Q_m} \beta^{Q_m}} + \eta^{Q_m *} \tag{3.27}$$

[22] Blau and Hagy (1998) provide an alternative specification where coefficients describing the effect of market variables $\boldsymbol{\Psi_t}$ are also state-specific. A step further in that direction would be including interactions between prices and marital status to capture the different responses of single and married mothers to market variables.

Quality of parenting is a latent variable for which we have several measurements throughout the relevant periods. These are items from the Home Observation for Measurement of the Environment (HOME) index[23] which include only household characteristics and parental attitudes that do not require direct use of income. Therefore at each assessment point associated with a particular period t we have a different measure $C_t^{Q_m}$ of the quality of parenting and $\widetilde{\eta_t^{Q_m}}$ is a measure-specific error:

$$C_t^{Q_m} = \gamma_{t0}^{Q_m} + \gamma_{t1}^{Q_m} Q_m + \widetilde{\eta_t^{Q_m}} \tag{3.28}$$

This specification gives a flexible framework for the measurement of the latent variable Q_m where instead of averaging all measures, we allow the data to determine the proper scale and weights $\gamma_{s0}^{Q_m}$ and $\gamma_{s1}^{Q_m}$ for each measure[24]. An interaction between quality of parenting and hours of free home care is included in the empirical specification of the production function for cognitive ability in order to capture the different effects Q_m and Q_r might have.

We also use the above framework for dealing with multiple measures of the cognitive outcome B_t at the age for enrollment in kindergarten:

$$C_s^B = \gamma_{s0}^B + \gamma_{s1}^B B_t + \widetilde{\eta_s^B}, \tag{3.29}$$

where C_s^B is the s^{th} measure for B_t and $\widetilde{\eta_s^B}$ is a test-specific measurement error[25]. To formulate the production function, we divide the early childhood in three developmental periods with respect to the effect of the inputs in each of them. The first is between 1 and 18 months, the second between 19 and 42 months and third between 43 and 57 months, where the first two periods consists of two equal in length subperiods each (9 and 12 months respectively) and the last one contains just one subperiod of 15 months. In fact, these subperiods are what we called in section 3.1 decision periods. Each of these decision periods is defined to contain a major assessment point

[23] This measure is described in detail in chapter 4.

[24] We do not estimate a separate equation for the quality of free home care, Q_h^f but that does not create endogeneity issues since its determinants (see equations (3.11) and (3.10)) enter the subset of state variables $\boldsymbol{\Delta_t}$.

[25] The multiple measures are subtest scores which we discuss in chapter 4

in NICHD SECCYD in which quality of paid day care and the home environment are observed. Although this classification is a result of the timing of assessments in the study, it can hardly be called arbitrary since those assessments were designed to reflect milestones in early child development (NICHD Early Child Care Research Network, 2001). While decision periods vary in length, choice variables have the same scale[26] and decision periods within a single developmental period contain the same amount of months. In contrast to Duncan and NICHD (2003), we use a richer time structure and allow for three distinct developmental periods instead of two.

While this specification is quite general, in this dissertation we only estimate the production function for cognitive skills at 57 months to capture the school-readiness of the child:

$$B_{57m} = \sum_{\tau=1}^{2} \boldsymbol{I_\tau \beta_I^{18m}} + \sum_{\tau=3}^{4} \boldsymbol{I_\tau \beta_I^{42m}} + \boldsymbol{I_5 \beta_I^{57m}} + \boldsymbol{X^B \beta_{X^B}} + \beta^B_{Q_m} Q_m + \eta^{B*}, \quad (3.30)$$

where the vector of subperiod inputs $\boldsymbol{I_t}$ is given by:

$$\boldsymbol{I_\tau} = [E_\tau \; K^p_{\tau d} \; K^p_{\tau d} F^p_{\tau d} \; K^p_{\tau d}(F^p_{\tau d})^2 \; K^p_{\tau d} Q^p_{\tau d} \; K^p_{\tau d} F^p_{\tau d} Q^p_{\tau d} \; K^f_{\tau d} \; K^f_{\tau d} F^f_{\tau d} \; K^f_{\tau d}(F^f_{\tau d})^2 \; K^f_{\tau d} Q^f_{\tau d}$$

$$K^f_{\tau d} F^f_{\tau d} Q^f_{\tau d} \; K^p_{\tau h} \; K^p_{\tau h} F^p_{\tau h} \; K^p_{\tau h}(F^p_{\tau h})^2 \; K^p_{\tau h} Q^p_{\tau h} \; K^p_{\tau h} F^p_{\tau h} Q^p_{\tau h} \; K^f_{\tau h} \; K^f_{\tau h} F^f_{\tau h} \; K^f_{\tau h}(F^f_{\tau h})^2 \; K^f_{\tau h} F^f_{\tau h} Q_m],$$

with K^k_{tc} denoting an indicator whether a particular mode of type c and payment status k has been adopted. We include interaction and quadratic terms for non-maternal care attributes to capture how the marginal products of quality and quantity of care vary for different combinations of those inputs within a particular mode of care. That is especially important for evaluating price and wage changes since it would introduce an additional factor that contributes to having unequal effects of those changes for households who differ in their use of childcare services[27]. The characteristics $\boldsymbol{X_B}$ correlated with the initial endowment δ_0 contain variables such as

[26] Hours are calculated as weekly averages.

[27] NICHD SECCYD also allows us to estimate equations for cognitive outcomes at an age younger than 57 months. However, those measures are likely to be much more noisy signals about child development while our primary focus remain school-readiness. Earlier measures would be beneficial for the value-added specification of the production function.

maternal cognitive ability, gender of the child and birth weight. Birth order is also included in order to account for the fact the child has to share parental resources with her siblings.

An admittedly strong assumption in our empirical framework is that if there are additional inputs determined by the household, their decision rules are not correlated with the choice of childcare attributes in the model. However, the version of the HOME questionnaire used in NICHD SECCYD and studied in detail by Dearing and Taylor (2007) seems to capture in a satisfactory way the presence of materials and goods related to early cognitive development E_t. We follow the the above mentioned study and obtain a measure of the level of the investment goods from the items in HOME which would require monetary input. More details on the construction of that measure and the one for parenting quality Q_m from HOME can be found in the next chapter[28].

The empirical framework described so far requires estimating a high-dimensional system of simultaneous equations with a particular pattern of correlation between their error terms. Additional estimation challenges arise from the panel structure of the data and the presence of both continuous and discrete outcomes. The approach adopted here utilizes a factor structure for the unobservables to capture the correlations between the equations in a way which makes estimation feasible despite the demanding features of the model. In that framework a particular disturbance term η_t^l for a decision rule l derived in equation (3.23) or the indirect utility in equation (3.20) in period t is represented as a weighted sum of the unobservable factors θ common to more than one equation and an idiosyncratic shock ϵ_t^l.

$$\eta_t^l = \sum_{a'=1}^{a} \rho_{a'}^{l_t} \theta_{a'} + \epsilon_t^l \tag{3.31}$$

By allowing factor loadings to vary with time we end up with a richer correlation

[28] Relaxing the above assumption and substituting the decision rules for those missing inputs in the cognitive ability equation would result in having prices and wages determining both choices and outcomes. Thus geographic markets will no longer serve as exclusion restrictions and identification of effects in the child attainment process will depend entirely on the correct specification of the joint distribution of the unobservables.

structure between the unobservables that accounts for the fact that the effect of the unobserved factors differ within and across periods. While Cunha and Heckman (2008) interpret the factors in their specification as latent variables measuring the stock of cognitive and non-cognitive skills and parental investment in early development, we do not attach a specific meaning to the common unobservables. Their sole purpose is to handle the correlations between all the equations which can arise from temporal shocks or permanent factors affecting several outcomes. The factors can have different distributions – normal, discrete, or mixture of normal distributions. Restrictions on the factors loadings ρ could provide empirical counterparts to certain theoretical constructs if necessary [29]. We can now complete the specification of the price and wage measures which guide the decisions of the mothers. Combining equations (3.4) and (3.24) with the error term formulation gives us the price constructs for day care center p^*_{td} and home care p^*_{th}:

$$p^*_{tc} = \overline{\boldsymbol{\Delta}^{(\boldsymbol{g})}_{\boldsymbol{t}}}\boldsymbol{\beta}^{\boldsymbol{p_c}}_{\boldsymbol{\Delta}} + \tilde{\boldsymbol{g}}\boldsymbol{\beta}^{\boldsymbol{p_c}}_{\boldsymbol{g}} + \sum_{a'=1}^{a} \rho^{p_{ct}}_{a'}\overline{\theta_{a'}} \tag{3.32}$$

In this way all mothers in the same market defined by time period and location are in fact responding to the same quality-adjusted price when making their decisions. On the other hand, the relevant wage component affecting choices is specific to the individual and contains her observed and unobserved characteristics obtained from equations (3.3) and (3.25)

$$w^*_t = \boldsymbol{X}^{\boldsymbol{w}}_{\boldsymbol{t}}\boldsymbol{\beta}^{\boldsymbol{w}} + \sum_{a'=1}^{a} \rho^{w_t}_{a'}\theta_{a'} \tag{3.33}$$

A similar structure for the error terms of the outcomes with multiple measures is

[29] To capture temporary shocks affecting household decisions we can allow for a new common factor originating in every period:

$$\eta^l_t = \sum_{\tau=0}^{t} \rho^l_\tau \theta_\tau + \epsilon^l_t$$

The unobservable term for an outcome at time t equals the weighted sum of all common factors θ_τ which appear in previous and current periods plus an idiosyncratic error. The ρ^l_τ's are the factor loadings which magnitude and statistical significance reveal how far in time a particular shock is transmitted.

incorporated. For quality of parenting and cognitive abilities we use the respective formulations for their unobservable parts:

$$\eta^{Q_m*} = \sum_{a'=1}^{a} \rho_{a'}^{Q_m} \theta_{a'} + \epsilon_t^{Q_m*} \tag{3.34}$$

$$\eta^{B*} = \sum_{a'=1}^{a} \rho_{a'}^{B} \theta_{a'} + \epsilon_s^{B*} \tag{3.35}$$

The additional assumption made here is that the terms $\epsilon_t^{Q_m*}$ and ϵ_s^{B*} are measure-specific as opposed to outcome specific[30]. That allows us to obtain the estimation equations for those last outcomes from equations (3.27), (3.28), (3.29) and (3.30) in which $\epsilon_t^{Q_m}$ and ϵ_s^{B} are idiosyncratic measurement errors[31].

$$C_t^{Q_m} = \gamma_{t0}^{Q_m} + \gamma_{t1}^{Q_m} \underbrace{\left(\boldsymbol{X^{Q_m}} \boldsymbol{\beta^{Q_m}} + \sum_{a'=1}^{a} \rho_{a'}^{Q_m} \theta_{a'} \right)}_{\widetilde{Q_m}} + \epsilon_t^{Q_m} \tag{3.36}$$

$$C_s^B = \gamma_{s0}^B + \gamma_{s1}^B \left(\sum_{t=1}^{2} \boldsymbol{I_t} \boldsymbol{\beta_I^{18m}} + \sum_{t=3}^{4} \boldsymbol{I_t} \boldsymbol{\beta_I^{42m}} + \boldsymbol{I_5} \boldsymbol{\beta_I^{57m}} + \boldsymbol{X^B} \boldsymbol{\beta_{X^B}} + \beta_{Q_m}^B \widetilde{Q_m} + \sum_{a'=1}^{a} \rho_{a'}^B \theta_{a'} \right) + \epsilon_s^B \tag{3.37}$$

3.2.4 Maximum Likelihood Estimation

The model is estimated by the maximum likelihood method after assuming that the idiosyncratic errors ϵ and the factors θ follow particular distributions and integrating the common unobservables θ out. To that end, we first form the contributions to the likelihood conditional on the vector of factors θ. We adopt extreme value distribution with mean zero for the idiosyncratic part $\epsilon_t^{V_j}$ of the disturbance $\eta_t^{V_j}$ in equation (3.20), which results in the following expression for the probability of choosing state j in

[30] This assumption has also been adopted by Bernal and Keane (2010) who use a simpler framework for multiple measures in which different measures differ only in their means.

[31] For identification purposes we have $\gamma_{11}^{Q_m} = 1$ and $\gamma_{11}^{B} = 1$.

period t for a mother i:

$$Pr_{it}(J_t = j|\theta) = \frac{\exp\left(\boldsymbol{\Delta_t}\boldsymbol{\beta}_{\boldsymbol{\Delta}}^{\boldsymbol{V_j}} + \boldsymbol{\Psi_{jt}}\boldsymbol{\beta}_{\boldsymbol{t\Psi}}^{\boldsymbol{V_j}} + \sum_{a'=1}^{a}\rho_{a'}^{V_{jt}}\theta_{a'}\right)}{\Gamma_t}, \tag{3.38}$$

where

$$\Gamma_t = \sum_{k=1}^{5}\exp\left(\boldsymbol{\Delta_t}\boldsymbol{\beta}_{\boldsymbol{\Delta}}^{\boldsymbol{V_k}} + \boldsymbol{\Psi_{jt}}\boldsymbol{\beta}_{\boldsymbol{t\Psi}}^{\boldsymbol{V_k}} + \sum_{a'=1}^{a}\rho_{a'}^{V_{kt}}\theta_{a'}\right) + 1.$$

The idiosyncratic error $\epsilon_t^{Z_{jlt}}$ for the l^{th} attribute Z_{jlt} associated with state j at period t follows a normal distribution with mean 0 and variance $\sigma^2_{Z_{jlt}}$ and thus equation (3.23) gives us the probability of that attribute conditional on θ and the mode j:

$$Pr_{it}(Z_{jlt}|\theta, J_t = j) = \frac{\phi\left(\left(Z_{jlt} - \boldsymbol{\Delta_t}\boldsymbol{\beta}_{\boldsymbol{\Delta}}^{\boldsymbol{Z_{jl}}} - \boldsymbol{\Psi_{jt}}\boldsymbol{\beta}_{\boldsymbol{t\Psi}}^{\boldsymbol{Z_{jl}}} - \sum_{a'=1}^{a}\rho_{a'}^{Z_{jlt}}\theta_{a'}\right)/\sigma_{Z_{jlt}}\right)}{\sigma_{Z_{jlt}}}. \tag{3.39}$$

Let $\widetilde{Z_{jlt}}$ is a variable indicating whether Z_{jlt} was actually observed in the data:

$$\widetilde{Z_{jlt}} = \begin{cases} 1, & \text{if } Z_{jlt} \text{ is observed} \\ 0 & \text{otherwise} \end{cases}$$

We are now able to construct the likelihood contribution of all attributes $Z_{\tilde{j}t}$ associated with a chosen state $\tilde{j}$ where only quality measures and investment in home goods are allowed to have missing values. We obtain

$$\begin{aligned} Pr_{it}(Z_{\tilde{j}t}|\theta, J_t = \tilde{j}) =& Pr_{it}(F_{td}^p|\theta, J_t = \tilde{j})(Pr_{it}(Q_{td}^p|\theta, J_t = \tilde{j}))^{\widetilde{Q_{td}^p}} \\ & \times Pr_{it}(F_{th}^f|\theta, J_t = \tilde{j})Pr_{it}(E_t|\theta, J_t = \tilde{j})^{\widetilde{E_t}}, \end{aligned} \tag{3.40}$$

when paid day care is chosen ($\tilde{j} = \{1, 4\}$),

$$\begin{aligned} Pr_{it}(Z_{\tilde{j}t}|\theta, J_t = \tilde{j}) =& Pr_{it}(F_{th}^p|\theta, J_t = \tilde{j})(Pr_{it}(Q_{th}^p|\theta, J_t = \tilde{j}))^{\widetilde{Q_{th}^p}} \\ & \times Pr_{it}(F_{th}^f|\theta, J_t = \tilde{j})Pr_{it}(E_t|\theta, J_t = \tilde{j})^{\widetilde{E_t}} \\ & \times Pr_{it}(F_{td}^f|\theta, J_t = \tilde{j})(Pr_{it}(Q_{td}^f|\theta, J_t = \tilde{j}))^{\widetilde{Q_{td}^f} \times I\left[F_{td}^f > 0\right]} \end{aligned} \tag{3.41}$$

when paid home care is chosen ($\tilde{j} = \{2, 5\}$), and

$$\begin{aligned} Pr_{it}(Z_{\tilde{j}t}|\theta, J_t = \tilde{j}) =& Pr_{it}(F^f_{th}|\theta, J_t = \tilde{j}) Pr_{it}(E_t|\theta, J_t = \tilde{j})^{\widetilde{E_t}} \\ & \times Pr_{it}(F^f_{td}|\theta, J_t = \tilde{j}) (Pr_{it}(Q^f_{td}|\theta, J_t = \tilde{j}))^{\widetilde{Q^f_{td}} \times I\left[F^f_{td} > 0\right]} \end{aligned} \tag{3.42}$$

when no paid care is chosen ($\tilde{j} = \{3, 6\}$). In a similar way, assuming that the idiosyncratic disturbances in the price equations, ϵ^{w_t}, $\epsilon^{p_{td}}$ and $\epsilon^{p_{th}}$, are normally distributed with means zero and variances $\sigma^2_{w_t}$, $\sigma^2_{p_{td}}$, and $\sigma^2_{p_{th}}$ respectively, we get the following probabilities for the observed wages prices:

$$Pr_{it}(w_t|\theta) = \frac{\phi\left(\left(w_t - \boldsymbol{X_w}\boldsymbol{\beta_w} - \sum_{a'=1}^{a} \rho^{w_t}_{a'} \theta_{a'}\right)/\sigma_{w_t}\right)}{\sigma_{w_t}} \tag{3.43}$$

$$Pr_{it}(p_{tc}|\theta) = \frac{\phi\left(\left(p_{tc} - \boldsymbol{\Delta_t}\boldsymbol{\beta^{p_c}_{\Delta}} - \tilde{\boldsymbol{g}}\boldsymbol{\beta^{p_c}_{g}} - \sum_{a'=1}^{a} \rho^{p_{tc}}_{a'} \theta_{a'}\right)/\sigma_{p_{tc}}\right)}{\sigma_{p_{tc}}}, \text{ where } c = d, h. \tag{3.44}$$

We can now complete the formulation of the contribution to the likelihood of a mother i who chooses state j in period t for all combinations of work and paid care mode described in our model and summarized in table 3.1:

$$\mathcal{L}_{it1}(\theta) = Pr_{it}(Z_{1t}|\theta, J_t = 1) Pr_{it}(J_t = 1|\theta) Pr_{it}(w_t|\theta) Pr_{it}(p_{td}|\theta) \tag{3.45}$$

$$\mathcal{L}_{it2}(\theta) = Pr_{it}(Z_{2t}|\theta, J_t = 2) Pr_{it}(J_t = 2|\theta) Pr_{it}(w_t|\theta) Pr_{it}(p_{th}|\theta) \tag{3.46}$$

$$\mathcal{L}_{it3}(\theta) = Pr_{it}(Z_{3t}|\theta, J_t = 3) Pr_{it}(J_t = 3|\theta) Pr_{it}(w_t|\theta) \tag{3.47}$$

$$\mathcal{L}_{it4}(\theta) = Pr_{it}(Z_{4t}|\theta, J_t = 4) Pr_{it}(J_t = 4|\theta) Pr_{it}(p_{td}|\theta) \tag{3.48}$$

$$\mathcal{L}_{it5}(\theta) = Pr_{it}(Z_{5t}|\theta, J_t = 5) Pr_{it}(J_t = 5|\theta) Pr_{it}(p_{th}|\theta) \tag{3.49}$$

$$\mathcal{L}_{it6}(\theta) = Pr_{it}(Z_{6t}|\theta, J_t = 6) Pr_{it}(J_t = 6|\theta) \tag{3.50}$$

In order to derive the probability for the series of parenting quality measure from periods 1 to T we define the vector of observed residuals and idiosyncratic errors

resulting from equation (3.36)[32]

$$\overline{\boldsymbol{C}}^{\boldsymbol{Q_m}} = \begin{pmatrix} \overline{C}_1^{Q_m} \\ \overline{C}_2^{Q_m} \\ \vdots \\ \overline{C}_T^{Q_m} \end{pmatrix} \quad \text{and} \quad \boldsymbol{\epsilon}^{\boldsymbol{Q_m}} = \begin{pmatrix} \epsilon_1^{Q_m} \\ \epsilon_2^{Q_m} \\ \vdots \\ \epsilon_T^{Q_m} \end{pmatrix},$$

where the t^{th} term of the first vector is given by.

$$\overline{C}_t^{Q_m} = C_t^{Q_m} - \gamma_{t0}^{Q_m} - \gamma_{t1}^{Q_m} \left(\boldsymbol{X}^{\boldsymbol{Q_m}} \boldsymbol{\beta}^{\boldsymbol{Q_m}} + \sum_{a'=1}^{a} \rho_{a'}^{Q_m} \theta_{a'} \right) \tag{3.51}$$

Assuming that the measure-specific errors are independent of each other and $\boldsymbol{\epsilon}^{\boldsymbol{Q_m}} \sim \mathcal{N}(\mathbf{0}, \boldsymbol{\Sigma}_{\boldsymbol{Q_m}})$, the probability of interest takes the form[33]:

$$Pr_i \left(C_1^{Q_m}, ..., C_{T^{Q_m}}^{Q_m} | \theta \right) = \frac{\exp\left(\left(\overline{\boldsymbol{C}}^{\boldsymbol{Q_m}\prime} \boldsymbol{\Sigma}_{\boldsymbol{Q_m}}^{-1} \overline{\boldsymbol{C}}^{\boldsymbol{Q_m}} \right) / 2 \right)}{(2\pi)^{T/2} \left| \boldsymbol{\Sigma}_{\boldsymbol{Q_m}} \right|^{1/2}} \tag{3.52}$$

We use a similar approach to derive the probability for all s^B subtests measuring cognitive abilities at 57 months of age by defining:

$$\overline{\boldsymbol{C}}^{\boldsymbol{B}} = \begin{pmatrix} \overline{C}_1^{B} \\ \overline{C}_2^{B} \\ \vdots \\ \overline{C}_{s^B}^{B} \end{pmatrix} \quad \text{and} \quad \boldsymbol{\epsilon}^{\boldsymbol{B}} = \begin{pmatrix} \epsilon_1^{B} \\ \epsilon_2^{B} \\ \vdots \\ \epsilon_{s^B}^{B} \end{pmatrix}$$

based on equation (3.37), where the s^{th} residual can be written as:

$$\overline{C}_s^B = C_s^B - \gamma_{s0}^B - \gamma_{s1}^B \left(\sum_{t=1}^{2} \boldsymbol{I_t} \boldsymbol{\beta}_{\boldsymbol{I}}^{\boldsymbol{18m}} + \sum_{t=3}^{4} \boldsymbol{I_t} \boldsymbol{\beta}_{\boldsymbol{I}}^{\boldsymbol{42m}} + \boldsymbol{I_5} \boldsymbol{\beta}_{\boldsymbol{I}}^{\boldsymbol{57m}} + \boldsymbol{X}^{\boldsymbol{B}} \boldsymbol{\beta}_{\boldsymbol{X}^{\boldsymbol{B}}} + \beta_{Q_m}^B \widetilde{Q_m} + \sum_{a'=1}^{a} \rho_{a'}^B \theta_{a'} \right) \tag{3.53}$$

[32] Such formulations do not require that all measures are observed for a particular individual. Naturally, missing measures would decrease the dimensions of $\overline{\boldsymbol{C}}^{\boldsymbol{Q_m}}$ and $\boldsymbol{\Sigma}_{\boldsymbol{Q_m}}$.

[33] While in this formulation $\boldsymbol{\Sigma}_{\boldsymbol{Q_m}}$ is a diagonal matrix, if the error $\epsilon_s^{Q_m}$ captures not only measure-specific noise but also unobserved characteristics of the parenting quality excluded from the common factors θ, the off-diagonal elements of $\boldsymbol{\Sigma}_{\boldsymbol{Q_m}}$ could be specified to reflect such a feature.

The measure-specific disturbances $\boldsymbol{\epsilon^B}$ are also assumed to be independent of each other and since $\boldsymbol{\epsilon^B} \sim \mathcal{N}(\mathbf{0}, \boldsymbol{\Sigma_B})$, the sought-after probability takes the following form:

$$Pr_i\left(C_1^B, ..., C_{s^B}^B | \theta\right) = \frac{\exp\left(-\left(\overline{\boldsymbol{C}}^{\boldsymbol{B}\prime}\boldsymbol{\Sigma}_{\boldsymbol{B}}^{-1}\overline{\boldsymbol{C}}^{\boldsymbol{B}}\right)/2\right)}{(2\pi)^{s^B/2}\left|\boldsymbol{\Sigma_B}\right|^{1/2}} \tag{3.54}$$

In order to describe the procedure for handling missing quality attributes for a mother i, we introduce the terms

$$\boldsymbol{I^B} = \begin{pmatrix} \boldsymbol{I_1} \\ \boldsymbol{I_2} \\ \vdots \\ \boldsymbol{I_5} \end{pmatrix} \quad , \quad \widetilde{\boldsymbol{I}}^{\boldsymbol{B}} = \begin{pmatrix} \widetilde{I}_1 \\ \widetilde{I}_2 \\ \vdots \\ \widetilde{I}_{I*} \end{pmatrix} \text{ , and } \quad \boldsymbol{\epsilon^{\tilde{I}}} = \begin{pmatrix} \epsilon_1^{\tilde{I}} \\ \epsilon_2^{\tilde{I}} \\ \vdots \\ \epsilon_{I*}^{\tilde{I}} \end{pmatrix}$$

in our notation as the vector of all inputs in the attainment function, the vector of missing attributes, and the idiosyncratic errors in the choice rules for those attributes respectively. The missing inputs $\widetilde{\boldsymbol{I}}^{\boldsymbol{B}}$ enter in $\boldsymbol{I^B}$ only with their linear form, i.e., their interactions with childcare hours are not included in this vector. Equation (3.23) gives the expression for the k^{th} missing input $\widetilde{I}_k$:

$$\widetilde{I}_k = \underbrace{\boldsymbol{\Delta_t}\boldsymbol{\beta}_{\boldsymbol{\Delta}}^{\tilde{\boldsymbol{I}}_{\boldsymbol{k}}} + \boldsymbol{\Psi_{jt}}\boldsymbol{\beta}_{\boldsymbol{t\Psi}}^{\tilde{\boldsymbol{I}}_{\boldsymbol{k}}} + \sum_{a'=1}^{a} \rho_{a'}^{\tilde{I}_k}\theta_{a'}}_{\widetilde{I}'_k} + \epsilon^{\tilde{I}_k} \tag{3.55}$$

Replacing $\widetilde{I}_k$ with its decision rule in $\boldsymbol{I^B}$ leads to having $\widetilde{I}'_k$ in in any observed residual for a measure s from equation (3.53). In that way we obtain $\widetilde{\boldsymbol{C}}^{\boldsymbol{B}}$,a modified formulation of $\overline{\boldsymbol{C}}^{\boldsymbol{B}}$, which is corrected for the missing quality. Furthermore, the idiosyncratic unobserved components from the missing attributes $\boldsymbol{\epsilon^{\tilde{I}}}$ together with the original measure-specific errors $\boldsymbol{\epsilon^B}$ form the vector of a new disturbance terms:

$$\boldsymbol{\epsilon^{\tilde{B}}} = \boldsymbol{\beta_{\tilde{I}}}\boldsymbol{\epsilon^{\tilde{I}}} + \boldsymbol{\epsilon^B},$$

where $\boldsymbol{\beta}_{\tilde{\boldsymbol{I}}}$ is the matrix of coefficients determining the effect of the missing inputs on the measures of cognitive development. Equation (3.37) shows that the elements $\boldsymbol{\beta}_{\tilde{\boldsymbol{I}}}$ are functions of the coefficients γ_{s0}^{B} and γ_{s1}^{B} characterizing each measure s, the relevant coefficients from the production function $\boldsymbol{\beta}_{\boldsymbol{I}}^{\boldsymbol{t}}$, and the value of variables with which the missing input is interacted. From our previously stated assumptions about the idiosyncratic errors in the decision rules for state-specific attributes we have $\boldsymbol{\epsilon}^{\tilde{\boldsymbol{I}}} \sim \mathcal{N}(\mathbf{0}, \boldsymbol{\Sigma}_{\tilde{\boldsymbol{I}}})$ and as a consequence $\boldsymbol{\epsilon}^{\tilde{\boldsymbol{B}}} \sim \mathcal{N}(\mathbf{0}, \widetilde{\boldsymbol{\Sigma}}_{\boldsymbol{B}})$, where the covariance matrix is given by:

$$\widetilde{\boldsymbol{\Sigma}}_{\boldsymbol{B}} = \boldsymbol{\beta}_{\tilde{\boldsymbol{I}}} \boldsymbol{\Sigma}_{\tilde{\boldsymbol{I}}} \boldsymbol{\beta}_{\tilde{\boldsymbol{I}}}' + \boldsymbol{\Sigma}_{\boldsymbol{B}}$$

The probability of the multiple measures of cognitive abilities takes the following form after correction for the missing inputs:

$$Pr_i\left(C_1^B, ..., C_{s^B}^B | \theta\right) = \frac{\exp\left(-\left(\widetilde{\boldsymbol{C}}^{\boldsymbol{B}\prime} \widetilde{\boldsymbol{\Sigma}}_{\boldsymbol{B}}^{-1} \widetilde{\boldsymbol{C}}^{\boldsymbol{B}}\right)/2\right)}{(2\pi)^{s^B/2} \left|\widetilde{\boldsymbol{\Sigma}}_{\boldsymbol{B}}\right|^{1/2}} \tag{3.56}$$

Such a correction of the covariance matrix allows us to incorporate the impact of the missing idiosyncratic shocks associated with the imputed inputs in a computationally inexpensive way, which does include integrating those shocks out. However, this approach would not work if missing past inputs enter current discrete choices. In this case one should either assume that the unobserved idiosyncratic components of quality are not not affecting parental decisions or integrate them out. While the second approach makes more theoretical sense, that would impose considerable computational burden on the estimation routine.

Given that the quality of free day care is exogenous to the decisions of the household, its idiosyncratic term is not considered in $\boldsymbol{\epsilon}^{\tilde{\boldsymbol{B}}}$ and following equation (3.26) Q_{td}^f is instead replaced by

$$\widetilde{Q}_{td}^f = \tilde{\boldsymbol{g}} \boldsymbol{\beta}_{\boldsymbol{g}}^{\boldsymbol{Q_d^f}} + \sum_{a'=1}^{a} \rho_{a'}^{Q_d^f} \overline{\theta_{a'}}$$

in the production function when it is missing.

To finalize the specification of the likelihood function, let

$$D_{tj} = \begin{cases} 1, & \text{if } j \text{ alternative is chosen at time } t \\ 0 & \text{otherwise} \end{cases}$$

Thus the contribution to the likelihood of a mother i becomes

$$\mathcal{L}_i(\theta) = \left(\prod_{t=1}^{T} \left(\prod_{j=1}^{J} \left(\mathcal{L}_{itj}(\theta)^{D_{tj}} \right) \right) \right) Pr_i \left(C_1^B, ..., C_{s^B}^B | \theta \right) Pr_i \left(C_1^{Q_m}, ..., C_{s^{Q_m}}^{Q_m} | \theta \right) \quad (3.57)$$

Integrating out the unobservable factor, taking the logarithm, and summing across individuals gives us the log-likelihood function:

$$\log \mathcal{L} = \sum_{i=1}^{N} \log \left(\int \mathcal{L}_i(\theta) \, dF(\theta) \right) \quad (3.58)$$

The empirical implementation of the model in this dissertation includes a single factor θ which has a normal distribution. Although it is undoubtedly a strong assumption which consequent work aims to relax, other studies have also adopted certain versions of it. For example, Bernal and Keane (2010) have used multivariate normal distribution for their unobserved heterogeneity, while Tekin (2007) has used a single factor with a discrete distribution for his childcare model[34]. In order to mitigate the effects of this assumption, the current framework includes period-specific factor loadings to allow correlation patterns to vary across time which previous work estimating jointly decision rules and cognitive production functions has not considered. The fact that any linear transformation of normally distributed variables also follows a normal distribution does not allow separate identification of the intercepts in the estimated equations and the mean of the distribution in question. In addition to that,

[34] Even though those studies make weaker assumption about the distribution of the unobservables, it is worth emphasizing that they are estimating less complex models. Tekin (2007) and Blau and Hagy (1998) have just one time period and no cognitive development functions, while Bernal and Keane (2010) do not consider the choice of childcare modes and quality of care. In our case the large number of parameters, combined with a correlation structure for the unobservables richer than the one utilized here lead to a significant problem of local maxima which produced unreliable estimates. This problem is discussed by Mroz (1999)

we can also identify only the product of a particular factor loading and the standard deviation of the factor. In the light of those restrictions the mean is normalized to 0 and the variance to 1. The integral term in (3.58) is approximated by Gauss-Hermite quadrature with 7 mass points described in detail in Butler and Moffitt (1982).

4

Data Sources and Variable Construction

4.1 Overview of the NICHD SECCYD dataset

Study design

There were 1,364 families enrolled in the NICHD SECCYD at its beginning in 1991. The sample was designed to represent healthy births to non-teen parents from diverse backgrounds in terms of ethnicity, education, family structure and economic background. Mothers were recruited during selected 24-hour sampling periods from 24 hospitals in the vicinity of 10 data collection sites across the country – Charlottesville, Virginia; Irvine, California; Lawrence, Kansas; Little, Arizona; Madison, Wisconsin; Morganton, North Carolina; Philadelphia, Pennsylvania; Pittsburgh, Pennsylvania; Seattle, Washington; and Wellesley, Massachusetts. The initial sample of 8,896 mothers was reduced to 5,416 when eligibility requirements were implemented (e.g., medical complications, multiple births, family lives too far away, baby put for adoption, etc.). This sample was further reduced by a subsampling plan designed to achieve the desired diversity to 3015. According to that plan each site was supposed to enroll at least 10% households with a single parent, 10% mother with less than a high school education, and 10% mothers from ethnic minorities. The final sample size

is reached after the exclusion of families who were planning to leave the area within 3 years, refused to participate in the survey, or the sites were unable to reach them[1].

NICHD Early Child Care Research Network (2001) compares the demographic characteristics of the sample with U.S. Census Tract data and finds that "on most demographic variables the study sample reflects the population of families with young infants residing in the communities from which research participants were recruited". There are, however, differences when it comes to education levels and income since the parents in the study on average have more years of education than the population in their census tracts. Furthermore, NICHD Early Child Care Research Network (2001) concludes that the sample is not nationally representative, since non-Hispanic children and families with higher income and education levels were overrepresented. For example, the percent of mothers in the sample with education of less than 12 years is 10.4, while for mothers nationwide giving birth in 1991 this number is 24.6%. Inspite of those weaknesses, Duncan and NICHD (2003) concludes that the sample is "large and economically, geographically, and ethnically diverse, especially for an observational child care study".

The complete study consists of four phases - Phase I (from birth through 3 years of age), Phase II (54 months of age through 1st grade), Phase III (2nd through 6th grades), and Phase IV (14 and 15 years of age). We use data only from the first phase and a part of the second phase, from the age of 43 months to 57 months when children are starting to enter kindergarten and several tests assessing school readiness were administered. In Phase I, data was collected at 5 major assessment points – 1 month after birth (enrollment), 6 months, 15 months, 24 months and 36 months. The locations at which those assessments were conducted included children's home, primary non-maternal childcare mode, and laboratory (e.g., for taking physical

[1] More details on the screening procedure can be found in NICHD Early Child Care Research Network (2001).

measures of the children or administering certain tests). Phone calls for additional data collection purposes were made every three months between assessments. In Phase II we use the data from the major assessment at 54 months of age, while the phone interviews relevant for the period analyzed here were conducted each four months between 42 and 54 months and at months 60 and 66.

Duncan and NICHD (2003) characterizes the attrition rates of the study as "modest". NICHD Early Child Care Research Network (2001) express the concern that that black families were more likely to drop out of the study. We report the retention rates for our sample after discussing in the next section what requirements the data for a certain mother should satisfy in order for her to be included in our empirical analysis.

Definition of periods and data construction approach

The vast majority of studies using the NICHD SECCYD dataset take advantage only of the measurements recorded at the main assessments points listed above since these are the only times when the home environment, the quality of childcare settings and the child's development are observed in detail (Duncan and NICHD, 2003; NICHD Early Child Care Research Network, 2003). In addition to that, even items from those assessments points are usually ignored if they ask for historical data on household activities and structure. For this reason, the measures included in the final analyses of those studies provide only a snapshot of the household at that particular point of time. Under the assumption that such a snapshot accurately represents the processes inside a broader time period encompassing that point, using that type of data should not pose a problem. However, the interview dates of the assessments show that despite the intentions of NICHD SECCYD to perform observations when children are at the same age, many observations were performed before or after the planned date. Therefore, according to the classification of NICHD SECCYD childcare choices

at the age of 36 months for some children are choices at 34 months, while for others – at 38 months.

An additional complication from the use of snapshot measurements is related to the fact that those major assessment points are not located at equal time intervals. As a consequence, if one discovers that childcare attributes recorded at the age of 54 months have a more significant impact on child development than attributes at 15 months of age, it is impossible to tell whether that was a result of the former period being more critical for skill formation or due to the fact that the latter is likely to represent a shorter time period given its proximity to assessments at 6 and 24 months of age.

To address these issues we explicitly define the start and end ages of every period in our framework. The number of decision periods is kept equal to the number of major assessments points, so that we have one childcare quality measurement at each period. Furthermore, the classification into the age groups (1) 0 to 9 months, (2) 10 to 18 months, (3) 19 to 30 months, (4) 31 to 42 months, and (5) 43 to 57 months ensures that the actual date of the main assessment is within the borders of its designated period, as well as that the length of decision periods within a single child development period is the same. The above classification is linked to our three developmental periods – (1) 0 to 18 months (infancy and early toddlerhood), (2) 19 to 42 months (mid- and late toddlerhood plus early preschool age) and (3) 43 to 57 months (mid- and late preschool age).

In order to obtain measures reflecting household choices and family structure characteristics within those strictly defined periods, first we construct month-by-month measures of the variables of interest. This is achieved through the use of all available dates of home visits and phone interviews, as well as dates on which the mother reports changing her employment status, number of working hours or childcare settings. Relevant information on maternal work-related outcomes, type and quantity

of childcare use, household composition, place of residence and partner's working history is matched across neighboring assessment points. For that purpose we utilize data from the phone interviews at the ages of 3, 9, 12, 18, 21, 27, 30, 33, 42, 46, 50, 60 and 66 months in addition to the commonly used variables from major assessments. The monthly constructs are subsequently the base for the period-specific measures which are averages (e.g., hours of paid home care a week) and fractions (*e.g*, mother lives with a husband/partner). A full list of the variables with their description and notation is included in table A.1.

In light of this study's focus on childcare choices, the sample of mothers for a particular period includes only households for which the childcare type and quantity decisions were observed in all previous and current periods. For example, a mother whose choices were not assessed after the child turned 2 years old would still enter the sample for age groups 0 to 9 months and 10 to 18 months. This feature of the data construction plan addresses the effect of attrition in the sample by keeping individuals in the sample for as long as the decisions outlined above are observed. We end up with 96.2% of the mothers from the original dataset for the age group 0 to 9 months, 93.8% for 10 to 18 months, 91.7% for 19 to 30 months, 90.4% for 31 to 42 months and 81.5% for 43 to 57 months. The last more substantial drop is due to the transition from Phase I to Phase II of NICHD SECCYD and the longer period between major assessments. 95.1% of the children who remain in our sample until its last month (or 76.6% of the original sample) have at least one observation of their cognitive skills.

4.2 Variables

Quality of non-relative care

The quality of non-maternal care, or more particularly its "process" dimension, is assessed through the Observational Record of the Caregiving Environment (ORCE) which is a live observational instrument especially designed for this study to address

the limitations of similar measures such as the Infant/Toddler Environment Rating Scale (ITERS), the Early Care Environment Rating Scale (ECERS) and the Family Day Care Rating Scale (FDCRS). In contrast to those other instruments, it is not a global composite score encompassing rather diverse features of the physical environment, social experiences, and working conditions, with potentially very different effects on the child's development. ORCE is also not tied to a specific childcare settings and therefore allows comparison across different arrangements such as family homes and day care centers, as well as assessment of in-home care provided by babysitters, nannies and grandparents[2].

We use the quality rating scores from ORCE which are based on the specific behaviors of the caregiver related to the sensitivity to child's non-distress expressions and stimulation of cognitive development (NICHD Early Child Care Research Network, 2001). Observers complete two 44-min cycles of ORCE and make qualitative ratings on a scale from 1 to 4 reflecting the degree to which the caregiver follows certain desired behaviors. The total quality composite score is the mean of the ratings recorded for the particular assessment period. For the assessments at 6, 15 and 24 months the evaluated desired behaviors are (1) sensitivity/responsiveness to non-distress calls, the extent to which caregiver-child interaction is characterized by prompt and appropriate responses to the child's social gestures, expressions, and signals; (2) detachment/disengagement (reflected), the degree to which the caregiver is emotionally and physically uninvolved with the child and unaware of the child's needs; (3) stimulation of cognitive development, the quality and frequency of caregiver effort to facilitate the child's cognitive development; (4) positive regard for the child, the quality and quantity of expressions to the child that connote the caregiver's positive feelings toward the child; and (5) flatness of affect (reflected), the frequency with which the caregiver lacks animation in facial and vocal expression and tone.

[2] See Vandell and Wolfe (2000) for a more detailed discussion of the advantages of the measure.

In addition to those ratings, the composite at 36 months includes (6) intrusiveness (reflected), the degree to which the caregiver imposes her agenda on the child as opposed to interacting in a way that provides a sense of control to the child; and (7) encouragement of the child's exploration of objects and the environment. At 54 months the score of interests is the average of only four subscales: (1) sensitivity, (2) detachment, (5) flatness of affect, and (6) intrusiveness.

NICHD SECCYD does not provide the ORCE instrument for all childcare arrangements utilized by the household. The first of the two reasons for this feature of the data has to do with the fact that only one setting is eligible for observation at any assessment point. It is usually the one in which the child spends the most time but there are also some additional requirements such as whether the arrangement is used for more than 10 hours a week or if the child has been there for at least two weeks prior to call arranging the assessment. Furthermore, priority is given to to certain types of settings, as it is in the case of day care centers at 54 months. The second reason for missing quality scores is that visits in some settings classified as eligible for observation fail to take place due to the refusal of the care provider. In our empirical approach we use ORCE quality ratings only for day care centers and paid home environments partly because of the fact that the criteria determining the childcare setting for observation are quite unfavorable for free home arrangements and therefore a very small proportion of them are actually assessed. It should be noted that the procedures for matching data across different assessments allows us to identify arrangements which are used in more than one period. When those arrangements were observed in just one of those periods, we use the same quality measures for the other periods as well. However, if the mother chooses a different provider but preserves the mode (e.g., paid day care center), we consider those separate arrangements which do not share the same quality.

The reason for having a missing measurement in this case is important since it

might be correlated with the quality of the arrangement. Table 4.1 provides more details on the patterns of missing quality values. Childcare settings are classified into three groups: (1) "not eligible" for observations or arrangements which did not meet NICHD SECCYD requirements for observations; (2) "not assessed" or arrangements which NICHD SECCYD wanted to observe but a visit could not be organized; and (3) "assessed" or arrangements which were actually observed. Most of the missing measures are associated with settings in which the child did not spend enough time in order to be considered for observation or the utilization of this arrangements was only between major assessment points. The total percentage of missing qualities is similar across modes and time periods but the fraction of failed visits is more substantial for home care environments. This is likely to stem from the fact that caregivers in less formal settings are less comfortable with such study visits.

Our approach of imputing all missing values implies that they are missing at random conditional on all observable characteristics and the common unobserved factors. With the joint estimation of the equations for quantity and quality we try to mitigate the effects of a potential scenario in which settings with different intensities might not be associated with qualities determined in the same way (i.e., the case of "not eligible" for observation arrangements)[3]. As for the eligible but "not assessed" arrangements, we try to improve on previous methods of imputation (e.g., multiple imputation in Dearing et al. (2009)) by using an approach based on a comprehensive theoretical model and allowing unobservables to determine the missing outcomes alongside observed characteristics[4].

[3] The sample includes quality measures on arrangements with fewer hours as well since our definition of intensity differs from the one used in NICHD SECCYD (i.e., we look at averages for longer periods) and for the age group 43 to 57 months priority for observation was given to day care centers even if the child spends less than 10 hours a week there.

[4] Another way to handle this issue is by looking for instruments which are correlated with the incidence of failed visits but orthogonal to household characteristics affecting choices. We hypothesized that interviews for establishing the childcare arrangement for observation which were too close to the deadline for conducting the site visit would be associated with a higher number of "not assessed"

Table 4.1: Patterns of Missing Non-relative Care Quality Measures by Age Groups

Type of Care	Status	0 to 9 m.		10 to 18 m.		19 to 30 m.		31 to 42 m.		43 to 57 m.	
		Obs. N / %	Mean Hours	Obs. N / %	Mean Hours	Obs. N / %	Mean Hours	Obs. N / %	Mean Hours	Obs. N / %	Mean Hours
Paid day care centers	Not eligible	49/32%	6.06	69/36%	8.48	105/37%	7.39	217/43%	6.37	209/33%	13.42
	Not assessed	8/5%	31.57	9/5%	23.20	19/7%	27.03	27/5%	30.32	49/8%	20.36
	Assessed	96/63%	27.13	115/60%	33.62	163/57%	34.23	260/52%	33.39	385/60%	24.19
	All	153 /100%	20.61	193/100%	24.14	287/100%	23.93	504/100%	21.59	643/100%	20.40
Free day care centers	Not eligible	4/44%	7.92	6/32%	7.06	14/47%	8.11	34/53%	8.45	45/31%	13.34
	Not assessed	1/11%	37.78	1/5%	12.22	1/3%	29.33	3/5%	19.36	11/8%	14.06
	Assessed	4/44%	26.81	12/63%	32.51	15/50%	31.57	27/42%	23.95	89/61%	20.11
	All	9/100%	19.63	19/100%	23.40	30/100%	20.55	64/100%	15.50	145/100%	17.55
Paid home care	Not eligible	161/34%	6.66	163/33%	9.66	148/33%	10.46	113/31%	10.15	77/35%	17.41
	Not assessed	80/17%	27.77	68/14%	32.89	64/14%	32.18	54/15%	34.68	22/10%	37.92
	Assessed	234/49%	26.33	259/53%	32.62	239/53%	33.22	200/54%	33.47	121/55%	32.59
	All	475/100%	19.91	490/100%	25.02	451/100%	25.60	367/100%	26.47	220/100%	27.81

Note: The percentages for each status are relative to all observations of the same type and age group.

Employment status, childcare modes and quantity of non-maternal care

The constructed working history of the mother provides measures of labor supply (in hours per week) and employment status. Similarly, the detailed records of childcare use show the modes of care used throughout the particular period and the weekly hours the child spends in each of them. A mode is defined based on the items describing the environment in which care takes place (home versus day care center), the relation of the caregiver to the child (mother versus other person) and the payment status (paid versus free). While the information on the location and the caregiver is available for all arrangements, the payment status of arrangements which started and ended between major assessments had to be imputed since the questionnaires for the phone interviews did not ask anything about prices. All arrangements where the caregiver is a relative were categorized as free. The payment status of all other arrangements were imputed based on their predicted probabilities of being free. Those probabilities were calculated using a probit model estimated on the sample of arrangements with non-missing payment status[5]. The details of this procedure can be found in Appendix B.

The quantity of childcare for each mode is measured in hours per week. In cases where the mother's labor supply is more than the childcare reported, the difference is added to the hours of free home care since our analysis of the data showed that in 88% of the cases discrepancies of this kind occur in families where the father, older children or grandparents live with the mother and the child[6]. In the few instances where both paid day care center and paid home care were observed in the same period, the hours

arrangements due to insufficient time for organizing the observation. However, that variable showed no effect on the probability of a conducted visit.

[5] Bernal and Keane (2010) use a very similar approach for predicting the missing childcare choices for some of the children's age groups in their sample.

[6] Alternatively, one could interpret such cases as situations in which the child is left unattended for some period time. However, that seems to be less probable given that the children in this study are less than five years old.

of the both arrangements were assigned to the more intensely used one.

Cognitive outcomes

We use five measures of children's cognitive skills at 54 months which are scores on subtests from the Woodcock-Johnson Psycho Educational Battery (Revised): Letter-Word Identification (skill at identifying letter forms and words), Incomplete Words (phonological knowledge), Memory for Sentences (assessment of short-term memory), Picture Vocabulary (ability to name objects), and Applied Problems (mathematical skill)[7]. Language and memory are cognitive processes found to be highly correlated with IQ scores and therefore psychologists (Neisser et al., 1996) have accepted them as good approximations of cognitive scores. For the choice of the other instruments we use the practice established in the economic literature[8] to consider math and reading test scores as measures of cognitive skills. Woodcock-Johnson Tests are also a common mean to assess school-readiness (Duncan et al., 2007). All scale scores were standardized by NICHD SECCYD to have a mean of 100 and a standard deviation of 15.

Measures of the home environment

The quality of the home environment is assessed using the Home Observation for Measurement of the Environment (HOME) inventory. The infant/toddler version of the measure was administered when the child was 6 and 15 months, while the early childhood version was administered at the ages of 36 and 54 months. Household characteristics ranging from parent-child interactions to provision of cognitive stimulating resources were captured through series of binary yes/no items such as "Ten or more children's books are available to the child", "Child is encouraged to learn the alphabet", "Mother usually responds verbally to child's speech", "Child has been

[7] See Woodcock (1990) for more details.

[8] See Cunha and Heckman (2008) and Bernal and Keane (2010)

taken to a museum during the past year" (Caldwell and Bradley, 1984; Bradley and Caldwell, 1988). The collected information was based on answers from the mother and direct observations by the interviewers.

This study uses HOME to construct the measures of the mother's parenting skill Q_m and the investment goods in child development E_t in period t. We utilize the approach in Dearing and Taylor (2007), which entails a very similar distinction between the items in this instrument. Our parenting quality variables (or in the terminology of Dearing and Taylor (2007) the "psychosocial environment" subscale) includes items on parental sensitivity and responsiveness (e.g., "Parent's voice conveys positive feelings toward child", "Mother praises child's qualities at least twice during visits"), learning stimulation (e.g., "Parent teaches child simple verbal manners") and lack of hostility (e.g., "Parent neither slaps nor spanks child during visit"). Since parenting quality is assumed constant from the child's birth to the age for enrollment in kindergarten, the sum of relevant items at each assessment point are treated as different measures of the same latent variable.

The measure of the goods facilitating early cognitive development (or the "physical environment" subscale in Dearing and Taylor (2007)) comprises features of the home structure (e.g., "House has 100 square feet of living space per person"), outings or activities provided to the child (e.g., "Child has been on a trip of more than 50 miles during last year") and learning materials (e.g., "3 or more puzzles are available to the child"). All items which require both psychosocial and financial investment are classified in this category since without the money spent they could not have been realized for any level of psychosocial investments. NICHD SECCYD could not administer HOME when the child was 24 months and therefore the measure of investment in development-enhancing goods for the relevant period uses the items from the neighboring major assessments at 15 and 36 months. To ensure comparability of measures across time, scores on the physical environment are standardized for each

period as in NICHD Early Child Care Research Network (2003). In addition to that, any measure constructed from HOME is considered non-missing only if it contains information on at least 70% of its items.

Family characteristics

The child's characteristics used here include gender, birth weight in kilograms and birth order, while the demographic variables related to the mother are her ethnic origin (African American or not), age, years of education and employment status before the child's birth (part-time or full-time). The verbal intelligence of the mother was assessed when children were 36 months old through the Peabody Picture Vocabulary Test – Revised (PPVT-R; Dunn and Dunn, 1981). The variables characterizing the family structure (fraction of the period in which the mother lives with a partner/husband, presence of an infant less than 6 months old in the household, number of adults and children living in the household) are obtained using the outlined matching data procedure.

The NICHD SECCYD dataset also includes various measures of maternal attitudes and beliefs which are likely to affect her work and childcare decisions, as well as her parenting style and investment in development-enhancing goods. One of the main advantage of using such instruments is the elimination of certain sources of unobserved heterogeneity present in studies using less detailed data. It is worth noting that the validity of all those instruments is strengthened by the fact that all of them were conducted when the child was one month old and therefore before she has experienced almost any kind of non-maternal care. Measures of the perceived costs and benefits of maternal employment to children are assessed through the relevant items from the Attitudes Towards Maternal Employment Questionnaire (Greenberger et al., 1988). For both instruments high scores indicate positive beliefs about the existence of such costs or benefits. Maternal attitudes and beliefs about childrearing were measured

using the subscore "Traditional beliefs" from the questionnaire "Ideas about raising kids" (Schaefer and Edgerton, 1985) with high scores reflecting traditional authoritarian beliefs of the mother. Another utilized instrument from the NICHD SECCYD which captures aspects of the mother's parenting perceptions is the Parental Locus of Control Scale. It measures parental efficacy, parental responsibility, child control of parent's live, parental belief in fate/chance, and parental control of the child's behavior (Campis et al., 1986). "Preference toward day care centers" and "Preference toward relative care" are dummy variables constructed from the items related to the mother's preferred mode of care at the home interview conducted when the child was 1 month old[9].

Wages, family income and costs of non-maternal care

At the major assessments points for ages 1, 6, 15, 24, 36, and 54 months mothers reported their annual household income from all sources including the ones we use here, i.e., wages of parents and income unrelated to government assistance. The hourly wage rate for the mother is calculated using her constructed working history. The average monthly contribution of the partner/husband's labor income to the household budget is formed based on the fraction of the period he spent living in the household. The assessment at age 54 months does not include information on the exact amount of money the household receives from non-labor income different from government assistance programs. Therefore, in order to make measurements comparable across periods, we utilize only the variables indicating whether a particular type of income (savings, rental property and broad "other investment income" category) has been received. The final measures of "other" income is the sum of those dummy variables[10]. A separate dichotomous variable for child support is included because of

[9] To our knowledge this is the first study using this information from the NICHD SECCYD dataset.

[10] Estimating the model with three different variables for each type of income did not alter results.

the close relation of this source of income to the structure of the household.

Mothers were also asked to report how much they pay for each type of care. To our knowledge, the only other study to use this part of the NICHD SECCYD dataset is Mongado (2007) who finds no major problems with the quality of that data. Hourly rates per child are calculated based on the amounts of hours parents reported together with the price and the number of kids included in the fee. Payments of zero dollars indicate free modes of care which in the case of a home environment setting corresponds almost always to care by a relative. The instances of free day care center arrangements[11] can be explained in 83% of the cases by the type of facilities the children are attending (i.e., association with a religious institution) and/or by parent reports of receiving subsidies and public assistance.

State policies and local market conditions

Indicator variables for each study site identify local childcare and labor markets. In addition to that, variables describing state-level government policies affecting the use of paid childcare were obtained from several sources. Maximum children-to-adults ratio in day care centers, maximum day care center group size, maximum children-to-adults ratio in family day care homes and maximum group size in family day care homes are part of the dataset on state regulations used in Hotz and Kilbourn (1994) and Hotz and Xiao (2011). State-level data from the 1992 and 1997 Census of Service Industries (O'Neill and O'Connell, 2001) measures the number of day care establishments per 1000 children, while state-level spending of the federal program Child Care Development Fund (CCDF)[12] for the years 1991 to 1996 is taken from Adams and Poersch (1996).

[11] The zero payment is also observed in other studies, e.g., Blau and Hagy (1998).

[12] CCDF assists low-income families in obtaining childcare.

4.3 Descriptive statistics

The descriptive statistics for household characteristics at the time of birth, discrete choices, time-varying outcomes, and measures of cognitive skills and parenting quality is presented in tables C.3, C.1, C.2 and C.4 respectively. About 86% of the mothers were married or living with a partner when the child was born, while 72% of them were working full-time before the birth. The average monthly contribution of the husband to the household budget is 3,170 (2000 CPI$) and around 8% of the women receive child support. The sample consists of 12% African American mothers at the beginning and 8% women who expressed preference toward day care centers. We discuss the statistics on households choices in the next chapter.

The empirical strategy adopted in this study hinges on geographic variation in prices of day care centers of home care. In the context of NICHD SECCYD's sampling design study site dummies are good candidates for local identifiers of separate childcare markets. The preliminary evidence summarized in tables 4.2 and 4.3 suggests that there is indeed a geographic component to the reported prices. The means of day care center and home care prices vary substantially across study sites – from $1.9 to $3.88 dollars per hour for the first category and from $1.56 to $3.47 for the second. Furthermore, higher levels of one type of prices are associated with higher levels for the other type as well, and in both cases the within-site variances are smaller than the overall variance for 8 out of the 10 sites. The fraction of the variance of day care center prices explained by location is 0.34, while for prices of home care that number is 0.25.

4.4 Empirical specification of the estimated equations

Our quasi-structural estimation frameworks serves as a guideline for deciding which variables determine a particular estimated outcome. A complete list of the exclusion

Table 4.2: Variation of day care center prices across locations

	Obs.	Mean	Variance
Site1	127	3.3186	1.4988
Site2	118	2.5121	0.8051
Site3	106	3.8851	1.3846
Site4	116	2.6869	1.0345
Site5	151	3.3503	1.5731
Site6	95	2.8749	0.989
Site7	166	3.4825	1.3083
Site8	198	1.9	0.3998
Site9	115	3.0816	0.9533
Site10	174	2.9606	1.4376
All	1366	2.8067	1.4537
Fraction of variance explained by location = 0.3366			

restrictions can be found in table A.2.They are a result of several model specification assumptions: (1) geographic location does not affect household preferences directly and determine only prices and wages[13]; (2) the child's initial endowment is correlated with her gender, birth weight, birth order and maternal innate ability measured by her PPVT score[14]; and (3) the time-invariant parenting skills of the mother are determined by her attitudes toward employment, beliefs about childrearing, preferences related to childcare and family structure at the time of birth[15].

[13] This is a standard assumption in the hedonic price literature – see Hagy (1998).

[14] In alternative specifications we used mother's age and/or mother's education as measurements of the innate ability but that did not change results.

[15] This specification is consistent with the approach adopted in Dearing and Taylor (2007).

Table 4.3: Variation of home care prices across locations

	Obs.	Mean	Variance
Site1	235	2.6965	1.2938
Site2	187	1.9524	0.7543
Site3	122	3.3058	1.3693
Site4	140	2.6487	1.2789
Site5	125	3.3603	2.2029
Site6	168	2.0155	0.9425
Site7	139	3.4692	1.4072
Site8	103	1.5699	0.7716
Site9	195	2.495	1.0229
Site10	174	2.5898	1.54
All	80	2.5395	1.5377
Fraction of variance explained by location = 0.2483			

5

Determinants of Households' Childcare Decisions

Policies designed to affect children's cognitive skills through changes in prices and wages can be effective only if they can create the right incentives for the households to choose childcare arrangements that are beneficial for the development of those skills. Since the child's cognitive development and the household budget constraints are not the sole considerations determining household childcare choices, assessing the direction and magnitude of parental responses to changes in market variables is vital for understanding the limitations of any potential policy relying on such changes. Given our focus on the wage and childcare changes on early cognitive outcomes and the fact that our data is not nationwide representative, in this chapter we do not try to provide an extensive empirical analysis of households' economic behavior. Instead, we present our estimates describing the impact of market variables on decision rules related to attributes of care that enter the production function for cognitive attainment and use section 5.6 to summarize the parents' substitution patterns across childcare characteristics relevant to the assessment the effect of wage rate and childcare price changes on early cognitive skills in chapter 7.

Throughout this chapter we also report results from a specification of the model

without unobserved heterogeneity in order to highlight the impact of controlling for selection bias. Details on the test rejecting the assumption of independence between the error terms included in the model are reported in table E.1. Table D.4 presents a summary of the coefficients characterizing the correlations between the disturbance terms.

5.1 Prices and wages

The results from the price equations reported in table D.1 confirm the preliminary findings in the previous chapter that the geographic identifiers have a statistically significant effect on prices. The coefficients for 7 out of the 9 site dummies are significant at the 5% level for day care center prices, while for the home care prices the corresponding number is 5. Table E.1 presents the results from tests rejecting specifications in which location related variables (i.e., site dummy variables and/or state-level policies) are excluded. The period dummies indicate lower prices in each subsequent period for day care centers but show no significant effects for home care. That is consistent with the price schedule of day care centers where costs are determined by child-to-staff ratios which go up with each subsequent age group.

In most of the cases the statistically significant household characteristics affecting prices are the same for both types of arrangements. Those include partner's income, maternal education, number of other children in the household, attitudes toward the cost of employment and traditional views toward childrearing. In terms of magnitude, the coefficients for all of those variables are bigger in absolute terms for the prices of home arrangements. For example, one additional year of mother's education is associated with 7.5 cents higher price of day care center and 10.2 cents higher price of home care. The opposite is true for location variables which impact is bigger for day care center prices[1]. Introducing unobserved heterogeneity does not affect considerably the

[1] That observation is consistent with the preliminary analysis in the previous chapter which showed

magnitude of the statistically significant coefficients with the exception of maternal education, where controlling for selection leads to more sizable coefficients for both types of care. For 7 out of the 10 factor loadings we observe statistical significance at the 5% level.

The results for the wage regression are reported in table D.2. All variables capturing previous work experience are significant and controlling for unobserved heterogeneity considerably increases the effect of work in the previous period (from 0.11 to 0.16), which is an outcome endogenously determined in the model, and therefore carries over the effect of past prices and wages. The significance of most of the site dummies suggests that local labor markets are responsible for part of the variation in earnings, unrelated to human capital measures, and, as a result, we cannot reject their validity as instruments on the basis of lack of explanatory power.

5.2 Discrete choice equation

The goodness-of-fit tests for the discrete choice equations are presented in table E.2. For each of the five age groups we cannot reject the hypothesis that the predicted choice probabilities are different from the actual shares of the states observed in the sample. The estimated coefficients for the discrete choice equation are shown in table D.3. Table 5.1 presents the marginal effects of wages, prices and period dummies for the aggregate categories "Work" (states 1, 2 and 3), "Paid day care center" (states 1 and 4), and "Paid home care" (states 2 and 5) at the means. The coefficients for the period dummies reveal that all other things equal, older children are more likely to attend day care centers. The patterns of paid home care use are more sporadic but there is a substantial decrease associated with the use of that mode for the age group of 43 to 57 months. Maternal employment rises after the child is no longer an infant and stays at the same level until the age for enrollment in kindergarten.

that site dummies explained a larger fraction of the variance of day care center prices.

Table 5.1: Discrete choice model: Price, wage and time effects (aggregate categories)

	Unobserved heterogeneity			No unobserved hetererogeneity		
	Work	Paid Day Care Center	Paid Home Care	Work	Paid Day Care Center	Paid Home Care
t_{10-18}	0.113^{***}	0.043	0.06	0.116^{***}	0.056^{*}	0.032
t_{19-30}	0.117^{***}	0.136^{***}	0.016	0.123^{***}	0.156^{***}	-0.01
t_{31-42}	0.117^{***}	0.341^{***}	-0.053	0.121^{***}	0.36^{***}	-0.061^{*}
t_{43-57}	0.101^{***}	0.522^{***}	-0.204^{***}	0.116^{***}	0.564^{***}	-0.181^{***}
LWage$\times t_{0-9m}$	0.399^{***}	0.131	0.524^{***}	0.323^{***}	0.152^{**}	0.381^{***}
LWage$\times t_{10-18m}$	0.233^{***}	0.097	0.433^{***}	0.193^{***}	0.14	0.272^{**}
LWage$\times t_{19-30m}$	0.223^{***}	0.073	0.456^{***}	0.19^{***}	0.142	0.284^{**}
LWage$\times t_{31-42m}$	0.291^{***}	0.039	0.357^{***}	0.254^{***}	0.15	0.2
LWage$\times t_{43-57m}$	0.407^{***}	0.05	0.231^{***}	0.354^{***}	0.094	0.119
PriceDC$\times t_{0-9m}$	-0.037^{***}	-0.182^{***}	0.084^{***}	-0.027^{***}	-0.142^{***}	0.061^{***}
PriceDC$\times t_{10-18m}$	-0.014^{**}	-0.183^{***}	0.103^{***}	-0.008	-0.142^{***}	0.071^{***}
PriceDC$\times t_{19-30m}$	-0.031^{***}	-0.235^{***}	0.136^{***}	-0.025^{***}	-0.201^{***}	0.102^{***}
PriceDC$\times t_{31-42m}$	-0.032^{**}	-0.212^{***}	0.144^{***}	-0.023^{*}	-0.16^{***}	0.099^{***}
PriceDC$\times t_{43-57m}$	-0.076^{**}	-0.094^{*}	0.056^{*}	-0.054^{*}	-0.049	0.031
PriceHC$\times t_{0-9m}$	-0.073^{***}	0.05^{***}	-0.173^{***}	-0.052^{***}	0.028^{**}	-0.119^{***}
PriceHC$\times t_{10-18m}$	-0.042^{***}	0.044^{**}	-0.111^{**}	-0.029^{***}	0.015	-0.043
PriceHC$\times t_{19-30m}$	-0.055^{***}	0.113^{***}	-0.217^{***}	-0.042^{***}	0.067^{**}	-0.142^{**}
PriceHC$\times t_{31-42m}$	-0.044^{***}	0.138^{***}	-0.179^{***}	-0.03^{***}	0.069	-0.094
PriceHC$\times t_{43-57m}$	-0.029^{***}	0.113^{***}	-0.133^{***}	-0.02^{**}	0.069	-0.079

Note: The marginal effects are estimated at the means of the observable characteristics and the unobservable factor.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

The effects of all market variables are significant for the specification with unobserved heterogeneity with the exception of the impact of wages on the use of paid day care centers. Both types of prices affect negatively employment and the use of the mode which they characterize, while wages have a considerable positive effect on labor force participation and paid home care utilization. Results also suggest that the paid modes of care are viewed as substitutes by the households since prices of center-based care is associated with higher incidence of paid home care and vice versa. In contrast to the price and wage equations, controlling for selection makes a difference in terms of the statistical significance and magnitude of the estimated effects. Most of the marginal effects of home care prices on the use of both modes of care are not statistically significant in the specification without unobserved heterogeneity. The

same is true for the impact of wage on paid home care utilization in the age groups from 31 to 42 months and from 43 to 57 months. In addition to that, the absolute values of all statistically significant effects are considerably larger in the specification allowing for common unobservables in the error terms. For example, the effects of day care prices on the use of any of the two modes care rise by more than 30%. This results confirm the validity of our empirical approach in terms of explicitly addressing selection and endogeneity problems related to childcare inputs.

We can use the results in table 5.1 to obtain effects which are comparable across choice categories and market variables[2]. For the specification with unobservable heterogeneity, a 15% increase in the wage would result in a 7.3 percentage points rise in paid home care use for infants. This number decreases to 3.2 percentage points for the age group between 43 and 57 months. A reduction of day care center prices of 15% is associated with 1.5 percentage points rise in labor participation and 7.7 percentage points increase in paid center-based care use for mothers of children in the age group between 0 to 9 months. An additional effect from such a price change is a decrease of the use of paid home care by 3.6 percentage points. The results from a similar 15% reduction of the day care center price for households with children between 43 and 57 months are increases in employment and day care center use by 3.2 and 4 percentages points respectively and a fall in the utilization of paid home care by 2.4 percentage points. The rise in labor participation resulting from of a 15% drop in home care prices varies between 1 and 2.7 percentage points across periods. The largest effects of home care prices on paid childcare use are for the age group between 31 to 42 months when a 15% fall in the price is associated with a decrease of 5.2 percentage points in the use of paid day care centers and an incrase of 6.8 percentage points in the incidence of paid home care.

[2] These effects are also estimated at the means of the observable characteristics and the unobservable factor.

In order to obtain estimates of price effects that can be compared to the ones obtained in previous studies, we also calculate the elasticity of employment with respect to the price of childcare. The simulation of a simultaneous 15% decrease in the prices of both types of care[3] for all mothers in the sample[4] leads to an increase in labor force participation by 2.7%, which produces an average elasticity of –0.18 across the available age groups. The closest estimates in the literature include –.121 in Tekin (2007)[5], –0.156 in Michalopoulos and Robins (2000), –.20 in Blau and Hagy (1998). There are fewer studies reporting the wage elasiticity of day care center use. Our estimates are obtained for each age group by simulating the effects of a 15% increase in the wage rate for decision period. The maximum value of 0.42 is attributed to the youngest age group and it is close to estimate of 0.44 reported by Blau and Hagy (1998). However, the average 0.16 for all five age groups is considerably lower and suggests that decisions of mothers regarding childcare modes are more sensitive to changes in the wage rate when the children are younger.

Table D.5 shows the marginal effects of prices and wages for all 6 discrete states which reflect substitution patterns within the broad categories discussed above. It is worth noting that the increase of wage is actually associated with substitution away from "Work & No paid care" and predominantly toward "Work & Paid home care". The exception is the oldest age group where higher wages lead to households substituting toward "Work & Paid day care center" as well. In addition to that, while a decrease in the price of day care centers results in higher probabilities of choosing any of the states involving a day care center mode ("Work & Paid day care center" and "No work & Paid home care"), an increase in the price of home care leads to

[3] A simulataneous decrease in both prices is similar to the decrease in the price for a single childcare option evaluated in most of the discussed studies.

[4] In this case the calculation of the measures is based on the average marginal effects instead of the marginal effects at the mean.

[5] The sample in that study includes only single mothers.

substitution away from "No work & Paid home care" and toward "Work & Paid home care".

Table D.6 presents the marginal effects of household characteristics on the probabilities of employment, day care center use and paid home care use. Married mothers are more likely to be employed and less likely to use paid home care, but only before their children reach two and a half years of age. In the last period of observation married mothers tend to choose paid day care centers less frequently than single mothers. The husband's income has a positive effect on the probability that the household chooses paid day care centers and a negative effect on the employment status of the mother[6]. In the first three decision periods higher income of the father is also associated with higher probability of paid home care use. The introduction of unobserved heterogeneity decreases the magnitude of all spouse income effects. On the other hand, the controls for other sources of income do not have a statistically significant impact. The older and more educated mothers in the sample are less likely to work or use paid home care holding their wage rates constant. More children in the household are associated with a lower probability of paid center-based care use for all age groups, while the negative impact of that household characteristic on employment and paid home care use is present only for the two youngest age groups. Black families choose paid home care less frequently and the number of adults in the household does not seem to affect choices. The strongest predictors of choices from the attitude measurements are the preferences toward day care centers, traditional views about child-rearing and the mother's beliefs about the costs and benefits of employment. Past work and childcare use history also have a considerable explanatory power over choices which suggests that affecting household choices closer to the birth of the child might have long-lasting effects.

[6] The quality of the data on income different from maternal labor compensation for households with children between the ages of 43 and 57 months did not allow us to pursue more reliable measures of income elasticities.

Table 5.2: Characteristics of care: Period, mode, and price coefficients for equations with time-varying price effects

	Unobserved heterogeneity				No unobserved hetererogeneity			
	Hours paid day care center	Hours paid home care	Hours free home care	Home goods	Hours paid day care center	Hours paid home care	Hours free home care	Home goods
t_{10-18}	-2.693	-8.46**	-0.65	-0.065	-10.475*	-9.748*	1.403	-0.057
t_{19-30}	-3.944	-1.563	-0.469	-0.181**	-7.685	-1.614	1.606	-0.179**
t_{31-42}	-0.707	-1.519	1.206	-0.121	-8.929	-3.72	3.11**	-0.122
t_{43-57}	3.807	-5.367	3.005**	-0.359***	-8.951	-10.436	5.207***	-0.376***
PaidDC$\times t_{0-9m}$	–	–	-11.915***	-0.358	–	–	-18.72***	-0.295
PaidDC$\times t_{10-18m}$	–	–	-8.574***	0.209	–	–	-14.172***	0.211
PaidDC$\times t_{19-30m}$	–	–	-8.779***	0.336*	–	–	-17.083***	0.313*
PaidDC$\times t_{31-42m}$	–	–	-8.294***	0.558***	–	–	-12.876***	0.514***
PaidDC$\times t_{43-57m}$	–	–	-6.938***	0.527***	–	–	-5.762**	0.443**
PaidHC$\times t_{0-9m}$	–	–	-9.861***	0.234	–	–	-12.243***	0.149
PaidHC$\times t_{10-18m}$	–	–	-9.033***	0.229	–	–	-14.331***	0.208
PaidHC$\times t_{19-30m}$	–	–	-9.57***	0.484**	–	–	-16.694***	0.418**
PaidHC$\times t_{31-42m}$	–	–	-7.617***	0.395*	–	–	-13.956***	0.358
PaidHC$\times t_{43-57m}$	–	–	-2.912	0.142	–	–	-4.96	-0.041
Work$\times t_{0-9m}$	2.812	-16.383***	12.018***	0.785***	7.298	-3.492	18.359***	0.822***
Work$\times t_{10-18m}$	-22.759***	-13.192**	11.173***	0.864***	-15.527*	-4.996	20.933***	0.893***
Work$\times t_{19-30m}$	-16.511**	-19.554***	12.192***	0.015	-11.93	-8.177	20.812***	0.107
Work$\times t_{31-42m}$	-11.855**	-20.04***	10.458***	0.192	-4.429	-7.815	20.397***	0.272
Work$\times t_{43-57m}$	-13.603**	-34.808***	8.655**	0.401	-6.909	-20.257*	15.44***	0.647**
LWage$\times t_{0-9m}$	2.818	9.192***	-0.172	-0.313***	2.31	5.689**	-2.171*	-0.329***
LWage$\times t_{10-18m}$	11.773***	8.465***	0.007	-0.33***	9.773***	6.471**	-2.42*	-0.342***
LWage$\times t_{19-30m}$	9.746***	9.376***	-1.277	0.031	7.942***	5.613*	-3.05**	-0.003
LWage$\times t_{31-42m}$	7.815***	9.776***	-0.993	-0.075	4.586*	5.641*	-3.536**	-0.103
LWage$\times t_{43-57m}$	7.993***	16.202***	-0.637	-0.112	4.95**	10.284***	-2.697*	-0.199*
PriceDC$\times t_{0-9m}$	-2.4*	–	1.585*	0.073	-4.126***	–	2.751**	0.054

	Unobserved heterogeneity				No unobserved hetererogeneity			
	Hours paid day care center	Hours paid home care	Hours free home care	Home goods	Hours paid day care center	Hours paid home care	Hours free home care	Home goods
PriceDC$\times t_{10-18m}$	-3.132**	–	1.034	-0.049	-3.476**	–	1.789	-0.051
PriceDC$\times t_{19-30m}$	-2.024**	–	1.528**	-0.076	-3.566***	–	3.495***	-0.069
PriceDC$\times t_{31-42m}$	-3.371***	–	1.009	-0.17***	-3.233***	–	2.207***	-0.154***
PriceDC$\times t_{43-57m}$	-5.182***	–	1.488*	-0.161**	-3.676***	–	1.372	-0.12*
PriceHC$\times t_{0-9m}$	–	-3.399***	1.001	-0.105	–	-1.883*	0.676	-0.074
PriceHC$\times t_{10-18m}$	–	-2.696***	1.456*	-0.096	–	-1.644	2.131**	-0.091
PriceHC$\times t_{19-30m}$	–	-4.13***	2.135**	-0.19**	–	-3.643**	3.317***	-0.168**
PriceHC$\times t_{31-42m}$	–	-3.999***	1.177	-0.123	–	-3.176**	2.549**	-0.111
PriceHC$\times t_{43-57m}$	–	-3.351*	-0.331	-0.057	–	-0.612	-0.009	0.026
Observations	1780	2003	6188	5957	1780	2003	6188	5957

Note: The (–) sign reflects a mode-specific variable not included in the particular outcome.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table 5.3: Characteristics of childcare: Marginal effects to the expected values

	Hours paid day care center	Quality paid day care center	Hours free day care center	Hours paid home care	Quality paid home care	Hours free home care	Home goods
t_{10-18}	0.896	-0.033	0.12	1.944*	0.021	3.177***	0.011
t_{19-30}	3.495***	-0.048	0.273**	1.079	0.006	1.731***	0.025
t_{31-42}	7.599***	0.129	0.349***	0.33	0.014	1.485***	0.023
t_{43-57}	9.667***	0.394***	1.249***	-3.223***	0.062	2.669***	-0.011
LWage$\times t_{0-9m}$	3.223*	-0.225*	-0.491***	13.451***	-0.195	-0.484	-0.301***
LWage$\times t_{10-18m}$	4.519**	-0.149	-1.447***	12.805***	-0.196	-0.193	-0.294***
LWage$\times t_{19-30m}$	4.904**	-0.144	-1.465***	13.15***	-0.186	-1.434	0.062
LWage$\times t_{31-42m}$	5.817**	-0.19*	-1.52***	11.353***	-0.202	-0.469	-0.036
LWage$\times t_{43-57m}$	8.04***	-0.183*	-2.42***	7.938***	-0.217	1.292	-0.049
PriceDC$\times t_{0-9m}$	-3.798***	0.068*	0.034**	1.562***	–	0.548**	0.04
PriceDC$\times t_{10-18m}$	-4.102***	0.062	0.064**	2.109***	–	0.558**	-0.026
PriceDC$\times t_{19-30m}$	-5.865***	0.053	0.147***	2.788***	–	0.73**	-0.056**
PriceDC$\times t_{31-42m}$	-6.471***	0.067*	0.223***	3.256***	–	0.775**	-0.096***
PriceDC$\times t_{43-57m}$	-5.947***	0.067*	0.445*	1.206*	–	0.557	-0.128**
PriceHC$\times t_{0-9m}$	0.914***	–	0.144**	-4.662***	-0.011	0.465	-0.038
PriceHC$\times t_{10-18m}$	0.827**	–	0.306***	-3.676***	-0.011	0.505	-0.037
PriceHC$\times t_{19-30m}$	2.428***	–	0.374***	-6.221***	-0.016	0.744**	-0.068**
PriceHC$\times t_{31-42m}$	2.89***	–	0.222***	-5.47***	-0.007	0.105	-0.042
PriceHC$\times t_{43-57m}$	2.082***	–	0.033	-3.565***	0.0007	-0.067	-0.006

Note: The marginal effects are estimated at the means of the observable characteristics and the unobservable factor. Expected values for qualities of paid modes are conditional on the mode being actually used.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

5.3 Hours of non-maternal care

Table E.3 compares the sample averages of childcare characteristics with the predictions generated by the estimated model. The evidence presented there suggests that the model produces a good fit for all measures of hours of non-maternal care[7]. The results for price and wage effects in the estimated equations for hours of paid day care centers, hours of paid home care and hours of free home care are presented in table 5.2. The effect of wages on both types of paid care is positive, while their impact on the use of free home care is insignificant. The last observation is in contrast to the results from the specification without unobserved heterogeneity where higher wage rates are associated with fewer hours of free home care. The price coefficients for the paid arrangements are negative and significant. The effect of a one dollar increase in the price of day care centers (or about 35% of the mean price) on the amount of hours spent by the child in this arrangement varies from a decrease of 2.02 hours for the age group between 19 and 30 months to a decrease of 5.18 hours for the oldest age group. Similarly, if the price of home care rises by one dollar (or about 40% of the mean price), that would result in an average drop in paid home care use of 3.52 hours across the five age groups[8]. Controlling for selection bias produces larger price effects for paid home care in all age groups, while for day care centers the same is true only for the two oldest age groups. All price coefficients which are significant in the equation for free home care are positive for the prices of both paid arrangements which is evidence that households substitute between the paid modes and free home care.

The specification of the estimated equations makes the effect of employment on

[7] The worst fit is obtained for hours in free day care centers but even there the maximum difference between the actual and the predicted mean is just 1/10 of the standard deviation of the variable in the sample.

[8] If not mentioned otherwise, the average effects reported in the description of the results in this chapter are the mean of the respective five effects characterizing each age group.

the hours used in each of the three modes contingent on the value of the wage rate. Using the results reported in table 5.2, we find that at the mean wage rates for each decision period working mothers use on average 8.62 more hours of paid center-based care and 7 more of paid home care in comparison to unemployed mothers who use those modes. Working mothers also use on average additional 9.3 hours of free home care when paid care is not used, additional 4.10 hours of free home care when paid center-based care is chosen, and additional 4.25 hours of free home care when the household uses paid home care.

Since prices and wages affect the discrete choices of employment and paid day care use as well, we estimated the marginal effects of those variables to the expected values of hours of non-maternal care. Table 5.3 reports the estimates of those measures which assess the total wage and price effects and account for the fact that some choices imply zero hours of particular childcare arrangements[9]. Although the signs of the effects remain the same, this set of marginal effects shows that the hours of paid home care for most of the age groups are more sensitive to changes in the wage rate than the hours of paid day care centers. Furthermore, the positive impact of center-based prices on the intensity of free home care is now more statistically significant. The marginal effects to the expected values also provide certain measures of substitution patterns between the modes and characteristics of care[10]. In terms of cross-price elasticities, a drop in the price of day care center by 1 dollar increases the use of paid home care by 2.18 hours on average, while a decrease of 1 dollar in the price of home care corresponds to an increase of 1.84 hours of paid center-based care utilization.

[9] For example, in the case of hours of center-based care the estimated marginal effect at the mean of the observables and the common factor is $\frac{\partial \mathrm{E}\left[F_{td}^{p}|\overline{\boldsymbol{\Delta_t}},\overline{\boldsymbol{\Psi_t}},\overline{\theta}\right]}{\partial \psi_{kt}}$, where by the law of total expectations $\mathrm{E}\left[F_{td}^{p}|\overline{\boldsymbol{\Delta_t}},\overline{\boldsymbol{\Psi_t}},\overline{\theta}\right] = Pr\left(J_t = 1|\overline{\boldsymbol{\Delta_t}},\overline{\boldsymbol{\Psi_t}},\overline{\theta}\right)\mathrm{E}\left[F_{td}^{p}|\overline{\boldsymbol{\Delta_t}},\overline{\boldsymbol{\Psi_{1t}}},\overline{\theta},J_t=1\right] + Pr\left(J_t = 4|\overline{\boldsymbol{\Delta_t}},\overline{\boldsymbol{\Psi_t}},\overline{\theta}\right)\mathrm{E}\left[F_{td}^{p}|\overline{\boldsymbol{\Delta_t}},\overline{\boldsymbol{\Psi_{4t}}},\overline{\theta},J_t=4\right]$.

[10] However, marginal effects at the means of the observable characteristics and the common unobservables do not capture the fact that the magnitudes and even the signs of the substitution patterns are likely to vary across individuals. Therefore, in chapter 7 we assess price and wage rate effects for three distinct groups in the sample and integrate over the common unobservable to obtain their final impact on cognitive development.

The period dummies show a rise in the use of paid day care centers and free home care for each subsequent period. While this effect is considerably lower for the free home care mode, it is entirely missing in the case of paid home care.

The wage and price coefficients for the hours of free day care center are in table 5.4 together with the results for the other equations, in which the number of observations were not enough to allow reliable identification of separate price and wage effects in each decision period[11]. In contrast to the other modes of care, the wage rate has a negative impact on the amount of time the child spends in that setting. That makes sense in the light of the fact that poorer families are likely to have a better chance of qualifying for such arrangements. On average employment is associated with additional 2.44 hours of free day care centers for mothers who do not use a paid type of care. The estimates of the marginal effects to the expected value in table 5.3 suggest that the negative impact of the wage rate on the use of free day care center is most significant for the oldest age group.

The marginal effects of the household characteristics are reported in tables D.7 and D.11. Married mothers use fewer hours of day care center and paid home care and more hours of free home care. The income of the husband has a negative effect on the use of paid day care center and free home care. Better education is associated with fewer hours of both types of paid care and more hours of free day care center. Black families tend to utilize fewer hours of paid home care and more hours of free home care, while a higher number of other adults in the household is associated with more hours of free home care and a reduced use of paid home care and free day care centers. The number of other children in the household has a negative impact on the hours of all types of non-maternal care with the exception of the free day care center mode where one more child in the household is linked to additional 0.15 hours in that arrangement. The effects of past employment is positive for all types of non-maternal

[11] There are only 28 cases of free day care center use in the first two age groups.

Table 5.4: Characteristics of care: Period, mode, and price coefficients for equations with constant price effects

	Unobserved heterogeneity			No unobserved hetererogeneity		
	Quality paid day care center	Quality paid home care	Hours free day care center	Quality paid day care center	Quality paid home care	Hours free day care center
t_{10-18}	-0.46	0.338	0.176	-0.106	0.434	0.139
t_{19-30}	-0.346	0.288	-0.51	-0.206	0.457	-0.519
t_{31-42}	0.077	0.48*	0.331	0.023	0.357	0.41
t_{43-57}	0.275	0.521	5.251***	0.136	0.463	5.491***
PaidHC$\times t_{0-9m}$	–	–	-1.055***	–	–	-0.865**
PaidHC$\times t_{10-18m}$	–	–	-3.06***	–	–	-2.75***
PaidHC$\times t_{19-30m}$	–	–	-3.215***	–	–	-2.866***
PaidHC$\times t_{31-42m}$	–	–	-4.34***	–	–	-3.873***
PaidHC$\times t_{43-57m}$	–	–	-9.388***	–	–	-8.736***
Work$\times t_{0-9m}$	0.203	0.507	1.677***	-0.159	0.237	1.207*
Work$\times t_{10-18m}$	0.688	0.492	1.863***	-0.093	0.077	1.206*
Work$\times t_{19-30m}$	0.591	0.566	2.356***	0.009	0.064	1.636**
Work$\times t_{31-42m}$	0.386	0.45	2.447***	-0.032	0.203	1.512*
Work$\times t_{43-57m}$	0.411	0.354	3.908***	0.093	0.06	2.698**
Lwage (w^{*})	-0.182	-0.199	-0.602**	-0.051	-0.091	-0.423*
PriceDC (p_d^{*})	0.061	–	–	0.012	–	–
PriceHC (p_h^{*})	–	-0.012	0.335**	–	-0.044	0.291**
Observations	1019	1053	4408	1019	1053	4408

Note: The (–) sign reflects a mode-specific variable not included in the particular outcome.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

care with the exception of free day care center. The use of paid care in the previous period is associated with more hours in paid home care and day care center and fewer hours in free home care.

5.4 Quality of non-maternal care

The estimates reported in table 5.4 do not imply statistically significant price and wage effects on the quality of paid day care. The signs of the coefficients indicate a negative impact of the wage for both modes, while a lower own price is associated with a reduction in quality of paid day care center and an increase of the quality of paid home care. This fact remains true regardless of whether we control for selection bias or not. The marginal effects to the expected values presented in table 5.3 show

a similar pattern in terms of the signs of the effects. However, the negative impact of wages on the quality of paid day care centers is now statistically significant at the 10% level for the youngest and the two oldest age groups. It should be noted that the size of the analyzed effects is rather small. A 15% increase in the wage rate produces an average decrease of 0.025 (or 0.05 standard deviations) in the quality of paid center-based care.The own marginal price effect to the expected value of the quality of day care center is also significant at the 10% level for the youngest and two oldest age groups. A reduction in the price of day care center of 1 dollar is associated with an average decrease in the quality of that mode of 0.063 (or 0.125 standard deviations).

The presented estimates of wage rate and price effects on hours and quality of care center provide evidence that quality and quantity of paid center-based care are not complementary goods, which is an important consideration for designing policies effective in producing early cognitive skills. Although that finding might seem surprising, the results in Blau and Hagy (1998) suggest that the parents in their sample even appear to view quality and quantity of care as substitutes in this particular mode. From the explanations consistent with our model, Blau and Hagy (1998) cite the possibility of consumers placing no value on quality as the most probable cause for the observed quantity-quality substitution. We can add to that the possibility that even if there is complementarity between hours and the "structural" characteristics of quality of care such as group size, the technology of producing "process" quality might lead to different substitution patterns between quantity and that "process" measure of quality. Such a scenario is plausible under the assumption that households make their choices only with respect to the more easily observable "structural" dimension of quality[12].

[12] Alternatively, there might be supply constraints preventing the household from realizing their most preferred choice. As Blau and Hagy (1998) note, in this case the estimates cannot be interpreted as revealing the preferences of households. Since our data is based on consumer reports, it is difficult to ascertain the validity of this explanation.

The results with respect to paid home care also do not suggest any complementarity between quality and quantity in that mode or a sizable effect of the market variables. However, while the impact of the wage rate is negative, as it is in the case of paid center-based care, here a decrease in the price of home care has a positive effect on quality. The effects of both market variables are not statistically significant.

The estimates reported in table D.11 suggest that household characteristics have a very weak explanatory power when it comes to the quality of paid day care centers. In fact, the only two statistically significant coefficients are the ones for maternal education and attitudes toward the benefit of employment. That is consistent with the above observation that households might not be able or are not willing to exercise considerable control over this dimension of center-based day care quality. The significant effect of state-wide regulation of day care center group size suggests that geographic location could be an important determinant in this case. On the other hand, most of the coefficients related to household variables are statistically significant in the equation for quality of paid home care. The income of the husband, the education of the mother and employment in the previous period are associated with a positive impact, while the number of other children and a history of paid care use affect quality of paid home care in a negative way[13].

5.5 Home environment

Although assessing the impact of the home environment variables is not one of the goals of this study, part of the total effect of price and wage changes on cognitive development comes through the impact on the home goods and the interaction of hours of free home care with maternal quality of parenting in the production function for skills. The results in tables 5.2 and 5.3 show a statistically significant negative effect of the wage rate on the home goods for the two youngest age groups. That might

[13] The estimated results for quality of free day care center is presented in table D.8.

reflect the fact that some of the items in that measure have a time component (e.g., "Child has been taken to a museum during the past year") and therefore higher wage rates can be associated with substitution of time away from providing development-enhancing experiences to the child and toward working longer hours. Nevertheless, with the exception of mothers with high wages, employment leads to a more enriching environment. The marginal effects of both types of prices to the expected value of home goods are negative but statistically significant only for the prices of day care center at ages groups from 10 to 42 months and for the prices of home care at age group from 19 to 30 months. Tables D.9 and D.10 present the estimates for the mother's parenting quality and its measures. Higher maternal education and husband's income at the time of birth are associated with higher quality of parenting while traditional values about childrearing and the presence of siblings have the opposite effect.

5.6 Summary of the results relevant to the assessment of the effect of wage and price changes on early cognitive development

The estimates of the parents' substitution behavior across types of care show that prices and wages affect the discrete choice related to the use of a particular mode of paid care and the number of hours the child spends in all non-maternal modes of care. The wage rate has a positive effect on the choice probabilities associated with both paid care modes, although this effect is statistically significant only in the case of home care. Its impact on hours of paid care is positive and significant for both center-based and home care. With respect to the free modes of care, the wage rate has an ambiguous effect on hours of home care and a negative one on hours of center-based care. Furthermore, higher wages are associated with less investment in an enriching home environment for children between the ages of 0 and 18 months and in most cases working mothers are likely to use more hours of each type of non-maternal care, regardless of whether they use a paid care arrangement as well.

Own prices affect negatively the probability of choosing the particular type of paid care and the number of hours of care associated with it, while cross-price elasticities between the two paid care modes are negative both with respect to of choice probabilities and quantity of care. In general, an increase in the price of both types of care have leads to more ours of free home care, but the effect is statistically significant only in certain decision periods. Unsurprisingly, mothers who use paid care arrangements use fewer hours of free home and center-based care.

Market variables do not have a statistically significant impact on the quality of paid care. This finding identifies a limitation to a policy utilizing changes in wages and prices to affect the cognitive skill of children – no matter how big those changes are, they can lead to better cognitive outcomes only through their effect on the quantity of non-maternal care alone. On the other hand, past work and childcare mode decisions have a statistically significant effect on almost all current childcare characteristics, which suggests that indirectly price and wage changes continue affecting choices in the next periods.

6

Childcare Inputs in the Production of Cognitive Attainment

The evidence presented in the previous chapter suggests that market variables such as prices and wages do indeed affect the choice of childcare characteristics when it comes to mode and hours of non-maternal care. In order to eventually assess what those effects mean in terms of the child's early development, this chapter discusses our findings related to the properties of the production function of cognitive skills. We focus our attention on identifying the modes of care most favorable to better cognitive attainment, the impact of the age, in which the child experiences the particular arrangement, and the variation of the marginal products of quality and quantity of both paid care modes across different combinations of those inputs in the production function of cognitive skills. Section 6.4 presents a summary of the results relevant to the assessment of the effect of wage rate and childcare price changes on early cognitive skills in chapter 7.

The comparison between the predicted and the actual means of the five measures of cognitive skills in table E.3 reveals that in this respect the model fits the test score part of the data quite well. We base our analysis predominantly on the specification of the

Table 6.1: Estimation results for the measures of cognitive skills

	C^B_{WJMS}	C^B_{WJAP}	C^B_{WJPV}	C^B_{WJIW}	C^B_{WJLW}
Unobserved heterogeneity					
Constant	84.658^{***}	95.26^{***}	93.446^{***}	91.797^{***}	93.052^{***}
Coefficient for B_{57m}	1	1.082^{***}	0.972^{***}	0.686^{***}	0.835^{***}
St. dev. of the error	14.953^{***}	10.422^{***}	10.715^{***}	11.436^{***}	10.064^{***}
Fraction of the variance explained by B_{57m}	0.345	0.556	0.493	0.297	0.448
Estimate of the mean of B_{57m}	7.07	7.116	7.02	7.085	7.051
Estimate of the st. dev. of B_{57m}	10.84	10.85	11.15	10.62	10.86
Ratio of st. dev. of B_{57m} to st. dev. of the subtest	0.588	0.694	0.722	0.796	0.802
No unobserved heterogeneity					
Constant	69.184^{***}	77.551^{***}	75.536^{***}	82.316^{***}	78.918^{***}
Coefficient for B_{57m}	1	1.124^{***}	1.097^{***}	0.636^{***}	0.888^{***}
St. dev. of the error	16.743^{***}	12.995^{***}	12.381^{***}	12.705^{***}	11.64^{***}
Fraction of the variance explained by B_{57m}	0.179	0.309	0.322	0.133	0.261
Observations	1049	1048	1055	1045	1051

Note: The coefficient in front of B_{57m} is normalized to 1 for Woodcock Johnson: Memory for sentences score.
The value of the standard deviation of B_{57m} used for the ratio of the standard deviation of B_{57m} to the standard deviation of the subtest is the average for the five subtests of 10.86.
The average of the estimates for the mean of B_{57m} in the presence of unobserved heterogeneity is 7.07.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

production function that includes a quadratic form for hours of care and interactions between quality and quantity for each type of arrangement. The validity of this approach is justified by the results of the likelihood ratio test described in detail in table E.1, which rejects the hypothesis that the specifications with and without non-linear terms in the production function are equivalent. However, in light of the potential issues related to identifying the precise form of non-linearity and the possible shortage of unique pairs of quality and quality values for each combination of age and childcare mode, we present the results from the linear specification as well[1].

[1] That also allows comparison with the results from previous studies (e.g., Duncan and NICHD

Table 6.1 reports the results describing the degree to which the subtest scores from the Woodcock-Johnson Psycho Educational Battery reflect the latent cognitive skills. The subtest score on "Applied problems" is the most sensitive to cognitive attainment at the age of enrollment in kindergarten with 0.556 of its variance explained by the variation in measured skills. On the other side of the spectrum is the score for "Incomplete words" where the explained fraction of the variance is 0.297. Very close estimates of the mean and standard deviation of the measure for cognitive skills are obtained for each subtest score by decomposing the subtest means and total variances to the component explained by those skills and the error term. Averaging those estimates for the latent cognitive measure out, we end up with an estimate for its mean of 7.07 and an estimate for its standard deviation of 10.86 as references for the quantitative impact of inputs in the production function. In order to simplify exposition, the discussion of the estimates below contains only the effects on latent cognitive abilities and the score for "Memory for sentences", since as a consequence of our normalization approach, the absolute point effects of inputs on both variables are the same[2].

Table 6.1 also presents some of the consequences from introducing unobserved heterogeneity in the model specification for the system of measures of cognitive attainment. Controlling for selection increases the fraction of the variance explained by the latent cognitive skills by 0.187 percentage points on average. In terms of the size of the fractions, this increase is most notable for "Incomplete words". Summary of the correlation coefficients between the test subscores and the inputs is presented in table F.1. Unobserved characteristics related to more intense use of paid care and free center-based care affect cognitive outcomes in a negative way, while somewhat

(2003)) which have not dealt with the effects of non-linearity in the context of cognitive attainment.

[2] All of those results can be easily converted for the other measures by multiplying them with the respective coefficient in front of B_{57m} for the effects expressed in terms of test points or with the ratio of the standard deviation of the latent cognitive skills to the standard deviation of the particular subtest score for the effects expressed in terms of the standard deviation of the dependent variable.

surprisingly unobservables associated with more hours in relative care have a positive impact on early skill development.

Table 6.2: Estimation results for the production of cognitive attainment

	Unobserved heterogeneity		No unobserved heterogeneity	
	No interactions	With interactions	No interactions	With interactions
Characteristics correlated with inborn ability				
CSex	-1.0787*	-3.4359***	-0.9905**	-1.0218**
MPPVT	0.07834***	0.06391***	0.13298***	0.13936***
CBord	-1.323***	-0.22937	-1.3432***	-1.3431***
CBWtg	-1.5832***	0.54524	1.2018***	1.068***
Quality of parenting (Q_m)	0.44698	1.3852***	1.3794***	1.2576***
Inputs for age groups t_{0-9m} and t_{10-18m}				
$F_{t,d}$	0.04604	0.60309***	-0.0133	0.31635
$(F_{t,d})^2$	–	-0.00752***	–	-0.00647***
$F^p_{t,h}$	0.10288***	0.40197***	-0.01861	-0.00046
$(F^p_{t,h})^2$	–	-0.00052	–	0.00192*
$F^f_{t,h}$	-0.17988***	-0.12365**	0.01144	-0.01109
$F^f_{t,h} \times Q_m$	–	0.00201	–	0.00514
$(F^f_{t,h})^2$	–	-0.0005	–	-0.00008
$Q_{t,d}$	2.8287***	4.6374**	0.99418	1.5332
$F_{t,d} \times Q_{t,d}$	–	-0.067	–	-0.01575
$Q^p_{t,h}$	2.3629***	5.0485***	0.59089	2.1562
$F^p_{t,h} \times Q^p_{t,h}$	–	-0.09566**	–	-0.04073
E_t	0.08692	0.15565	0.25885*	0.22683
$K_{t,d}$	-10.2747***	-16.8323***	-3.0257	-6.1101
$K^p_{t,h}$	-9.3001***	-16.327***	-0.42378	-4.0136
Inputs for age groups t_{19-30m} and t_{31-42m}				
$F_{t,d}$	0.15567***	0.29199*	0.00624	-0.29333
$(F_{t,d})^2$	–	0.00115	–	0.00058
$F^p_{t,h}$	0.15542***	0.516***	0.02579	-0.12954
$(F^p_{t,h})^2$	–	0.00242	–	0.00241**
$F^f_{t,h}$	-0.2463***	-0.20427***	0.00434	-0.03298
$F^f_{t,h} \times Q_m$	–	0.00876	–	0.00789
$(F^f_{t,h})^2$	–	-0.00142*	–	0.00014
$Q_{t,d}$	3.6717***	5.5208**	1.1892*	-1.7764
$F_{t,d} \times Q_{t,d}$	–	-0.0799	–	0.09708
$Q^p_{t,h}$	4.3029***	8.6891***	1.8528***	1.6489
$F^p_{t,h} \times Q^p_{t,h}$	–	-0.15887***	–	0.0138

	Unobserved heterogeneity		No unobserved heterogeneity	
	No interactions	With interactions	No interactions	With interactions
E_t	0.84921***	0.68332***	0.86537***	0.90405***
$K_{t,d}$	-13.3643***	-17.2208***	-3.1732*	5.511
$K^p_{t,h}$	-16.5677***	-28.0889***	-6.3936***	-4.8625
Inputs for age group t_{43-57m}				
$F_{t,d}$	0.09064***	0.05661	0.02669	-0.07252
$(F_{t,d})^2$	–	0.00487**	–	0.0044***
$F^p_{t,h}$	-0.02018	0.82881***	-0.03083	0.49958**
$(F^p_{t,h})^2$	–	-0.00017	–	-0.00428*
$F^f_{t,h}$	-0.13589***	0.11661	-0.04328**	0.10258
$F^f_{t,h} \times Q_m$	–	-0.03625**	–	-0.02515**
$(F^f_{t,h})^2$	–	-0.00292***	–	-0.00078
$Q_{t,d}$	2.7288***	4.6018***	0.92215*	1.7959*
$F_{t,d} \times Q_{t,d}$	–	-0.08044*	–	-0.03774
$Q^p_{t,h}$	3.4375**	8.3435***	0.24928	3.372
$F^p_{t,h} \times Q^p_{t,h}$	–	-0.27482***	–	-0.10854
E_t	0.89073***	0.56199	1.2074***	1.1928***
$K_{t,d}$	-8.1608***	-12.1632***	-2.351	-3.2906
$K^p_{t,h}$	-8.648**	-24.807***	-0.4159	-11.0908*
Factor loading	-13.8279***	-13.4461***	–	–
Observations	5248	5248	5248	5248

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

6.1 Inputs in center-based care

The estimates of the production function for cognitive skills are reported in table 6.2[3]. The introduction of a common unobservable has a considerable impact on the statistical significance and magnitude of almost all coefficients. In contrast to the specification without unobserved heterogeneity, where the only significant inputs in this mode are the squared terms of average weekly hours in the first and third developmental periods, once we control for selection, almost all effects are significant, with the exception of some of the coefficients for the quadratic forms and the linear term

[3] Note that, as we discussed in chapter 2, in the context of the production function of cognitive attainment we distinguish between three developmental periods instead of the five periods for household choices: from 0 to 18 months, from 19 to 42 months and from 43 to 57 months.

for hours of care in the last period[4].

Table 6.3: Marginal effects of quality and quantity of center-based and paid home care (on yearly basis)

	With interactions			No interactions
	Values of Q^p_{tc}			
	Mean - 1 SD	Mean	Mean + 1 SD	
Age groups t_{0-9m} and t_{10-18m}				
F_{td}	0.1601	0.1130	0.0654	0.0614
Q_{td}		4.1657		3.7716
F^p_{th}	0.2088	0.1335	0.0583	0.1372
Q^p_{th}		3.8616		3.1505
Age groups t_{19-30m} and t_{31-42m}				
F_{td}	0.1663	0.1287	0.0919	0.1557
Q_{td}		3.7278		3.6717
F^p_{th}	0.2667	0.1841	0.1014	0.1554
Q^p_{th}		4.5601		4.3029
Age group t_{43-57m}				
F_{td}	0.0451	0.0091	-0.0269	0.0725
Q_{td}		2.3687		2.1830
F^p_{th}	0.1255	0.0002	-0.1252	-0.0174
Q^p_{th}		0.5606		2.75

Note: The marginal products are evaluated at the average number of hours for which the arrangement was used in the particular period.
The three columns below "Values of Q^p_{tc}" report estimates of the marginal products for three different values of the relevant childcare mode quality.

As figure F.1 shows, the marginal product of hours of care in the production function of cognitive skills decreases with prolonged use of the setting in the first developmental period and becomes negative around 28 hours per week at an arrangement with average quality. For the other two periods more intensive use of center-based care has a positive effect on the marginal product of quantity. However, each additional hour of care in the third age group has a positive impact on cognitive attainment

[4] All marginal products reported below naturally imply keeping all other inputs fixed. In case of intensity of childcare, this means holding the investment in home environment constant regardless of the implied changes in the hours of maternal care. This is a strong assumption (see Bernal and Keane (2010)) which impact we try to mitigate in the next chapter by accounting for the effect of employment and day care use on home inputs in assessing the effect of price changes on early development.

only for arrangements in which the child spends more than 20 hours a week (see figure F.1). In all periods the effect of quality on the marginal product of hours of care in the production function of cognitive skills is negative, although this effect is significant only for the age group from 43 to 57 months. In order to make all effects comparable in size across developmental periods, we scale them on a yearly basis[5] and present the results in table 6.3. For example, an additional hour of center-based care in the first developmental period for the average period-specific values of quantity and quality is associated with an increase of 0.113 points in the cognitive skills and the subtest score, which translates into increases of 0.010 (=0.113/10.86) and 0.006 (=0.113/18.47) standard deviations of each of those two outcomes respectively[6]. The magnitude of the marginal products of hours of care evaluated at the average intensity are similar for all children between 0 and 42 months. However, as figures F.1 and F.2 show, the estimates for that effect differ substantially when evaluated at one standard deviation above and one standard deviation below the average hours of center-based care. On the other hand, while the value of the marginal product of hours at the average intensity for the age group from 43 to 57 months is below the corresponding estimate for the second period, the two estimates almost converge at forty hours of care a week, i.e., 0.169 points for the middle period (0.016 standard deviations of the cognitive skills and 0.0091 standard deviations of the subtest score) and 0.162 points for the last period.

The variation of the marginal product of quality evaluated at the average hours of care is shown in figures F.7, F.8 and F.9 for the three age groups. In all cases

[5] Our scaling uses the fact that the first developmental period includes 6 subperiods of 3 months, the second one – 8 subperiods of 3 months and the third one – 5 subperiods of 3 months. Applying the respective multiplier to get a yearly basis works in this case only when the weekly values of inputs, on which we condition the measured effects, are the same for each of the subperiods associated with a considered change in the input.

[6] Similarly, we divide the marginal product of hours of care in table 6.3 by the standard deviation of cognitive skills and "Memory for sentences" subtest score for each subsequently reported marginal product of hours of care.

the effect of quality decreases for higher intensity of center-based care use but the only statistically significant effect is in the last period where the marginal product of quality drops from 3.355 for hours of care one standard deviation below their mean to 1.382 for hours of care one standard deviation above the mean. According the those numbers, at the lower value of hours one standard deviation change in quality is associated with 0.173 (=3.355×0.56/10.86) and 0.102(=3.355×0.56/18.47)[7]. standard deviation changes in cognitive skills and subtest scores respectively. For hours of care one standard deviation above their mean, the respective values of those effects are 0.071 and 0.042 standard deviations. This is comparable to the effect sizes[8] of 0.04 to 0.08 which Duncan and NICHD (2003) find for all cognitive and achievement measures in the same dataset for children in preschool age. The effect size of quality in the first age group evaluated at the average hours is 0.204 for the cognitive skills and 0.12 for the subtest score, while the corresponding numbers for the second developmental period are 0.158 and 0.093 respectively. Those effect sizes suggest that earlier periods are more sensitive for the child's cognitive development when it comes to the effect of day care quality[9]. Therefore, policies introduced in those periods and resulting in higher levels of quality in center-based care would be especially effective in stimulating the cognitive development of children. However, as we have already noticed in chapter 5, changes in wage rates and childcare prices are not capable of achieving that due to their almost non-existent effect on the households'

[7] In those formulas 0.56 is the standard deviation of quality of paid center-based care for children between 43 and 57 months old from table C.2, while the denominators are the standard deviations of cognitive skills and the "Memory for sentences" subtest score. All other measures of the marginal product of quality expressed in standard deviations are obtained in a similar way.

[8] We use the term "effect size" to define the number of standard deviations by which the outcome changes as a result of one standard deviation change in the input.

[9] It should be noted that the high negative values of the coefficients in front of the indicator variables for use of center-based or paid home care arrangement are likely to predict too low values of cognitive attainment for children who spend very few hours in low quality settings. Nevertheless, it is not clear whether that would have any effect on the assessment of the marginal changes which are the focus of this study.

demand for quality.

6.2 Inputs in paid home care

Controlling for selection produces more statistically significant and sizable coefficients in the case of paid home care as well. Almost all significant effects from the specification without unobserved heterogeneity are concentrated in the third developmental period, i.e., the coefficients for the indicator of paid home care, the linear and the quadratic terms for hours. In contrast to the case of center-based care, none of the quadratic forms for hours of care are statistically significant. However, the interaction terms between quality and quantity have p-values less than 0.05 for all developmental periods.

The variation of the marginal product of hours is presented in figures F.4, F.5 and F.6. While the effects for the first two age groups show certain similarities, the last age group seems to be rather different. Using the estimates in table 6.3, we see that in the first developmental period the marginal product of an additional hour of paid home care evaluated at the average intensity varies from from 0.209 points (0.019 standard deviations of cognitive skills or 0.011 standard deviations of the subtest score) for quality one standard deviation lower than the average, to 0.065 points (0.005 standard deviations of cognitive skills or 0.003 standard deviations of the subtest score) for quality one standard deviation above the average. The same effects for the second developmental period are 0.267 points (0.025 standard deviations of cognitive skills or 0.014 standard deviations of the subtest score) and 0.101 points (0.01 standard deviations of cognitive skills or 0.005 standard deviations of the subtest score) respectively. The measures of the impact of hours differ substantially for the last period, where the value of the marginal product for the average quality is virtually zero and the effect for quality one standard mean higher than the average is negative (-0.125 points or -0.012 standard deviations of cognitive skills).

Figures F.10, F.11 and F.12 show the marginal product of quality as a function of hours of paid home care. The effect size of quality on cognitive skills for the first age group is 0.314 (0.186 for the subtest score) when evaluated at 7.5 hours or one standard deviation below the average hours for the period[10], and 0.098 (0.057 for subtest score) when evaluated at 37.5 hours or one standard deviation above the average hours. For the second age group the corresponding numbers are 0.338 (0.2 for the subtest score) at 5.5 hours and 0.098 (0.057 for the subtest scores) at 39 hours, while for the age group between 43 and 57 months we have an effect size of 0.204 (0.12 for the subtest scores) at 5 hours and a negative effect size of 0.144 (0.085 for the subtest scores) at 36 hours. In fact, the marginal product of quality is negative for the age group of 43 to 57 months for any amount of hours above 30. While the results from the early age groups resemble to some degree the ones obtained for the center-based care mode, the estimates pointing to a negative effect of quality for the oldest children in paid home care arrangements of higher intensity seem counterintuitive. A possible explanation of this puzzling result is that there are fewer observations for quality in paid home care arrangements in the last developmental period which makes identification of the non-linear terms more difficult[11]. The specification without interactions shows statistically insignificant effect of paid home care quantity and a significant positive marginal product of paid home care quality 1.26 times bigger that the marginal product of quality of center-based care for the same specification.

In terms of the general properties of the production function for cognitive attainment, the negative relation between the marginal product of quality and the hours of care implies that the impact of more positive interactions with the caregiver faces

[10] We use the formula discussed in footnote[7].

[11] There are three reasons for the lower number: (1) the last developmental period contains only one assessment of quality while each of the other ones contain two, (2) fewer people use paid home care at this age of the child and (3) priority for observation is given to day care centers. Thus the number of observations for the third period is 121, while the number for the first and second periods is 493 and and 439 respectively.

limitations for children who spend a lot of time in day care settings. It might be the case that although there are benefits associated with the use of center-based or paid home care (e.g., exposure to different experiences, interaction with peers, etc.), their scope is limited and it is reached faster if the quality of the setting is high. Our primary interest, however, lies in revealing the pattern of input changes which are beneficial for cognitive development. The signs of the marginal products discussed above show that in the majority of cases policies which goal is to facilitate the formation of cognitive skills would benefit from creating incentives for the household to choose more hours and quality at the same time. On the other hand, the evidence presented in the previous chapter that prices and wages have little effect on the quality of both types of care suggests that eventually we might have to settle for wage and childcare price changes which affect only the intensity of care in the desired way, but the net effect of those changes on cognitive development is positive. Furthermore, these considerations might prove to be of second-order importance given the additional substitutability across modes and types of inputs. For example, even if a price change increases both the quality and quantity of paid home care when this is advantageous, the positive impact of such a change on cognitive development might be outweighed by the corresponding effect of home inputs and free home care use.

6.3 Free home care, home inputs and characteristics correlated with the initial ability endowment

The effects of free home care use are bigger in magnitude and more statistically significant for the specification of the model with unobserved heterogeneity, especially in the case of the first two developmental periods. The quadratic form is negative and significant for the second and third age groups, while the same is true for the interaction term between hours of free home care and parenting quality only in the last period. In our specification of the model, the quality of relative care is a function

of the quality of parenting and therefore the goal of interacting of hours in relative care with that measure of home environment is to capture the differences in the qualities of those types of care. Such interpretation of the coefficient implies that the inability of relatives to provide quality of care comparable to the levels of the maternal care starts to play a more prominent role at the age when most of the children are already experiencing some form of care from a non-relative. On yearly basis the effect of an additional hour in home care at the average value of hours and quality of the home environment is -0.168 points for the first developmental period (-0.016 standard deviations of cognitive skills or -0.009 standard deviations of the subtest score) and -0.196 points for the second (-0.018 standard deviations of the cognitive skills or -0.011 standard deviations of the subtest score) and -0.103 points for the third (-0.01 standard deviations of the cognitive skills or -0.006 standard deviations of the subtest score). Those estimates suggest that substitution away from relative care can prove advantageous for the child's cognitive development.

Quality of parenting has a statistically significant impact on the production of cognitive attainment and is associated with an effect size of 0.223 for cognitive skills or 0.132 for the subtest score. The effects of the measures of home goods are positive for all age groups but significant only for the age between 19 and 42 months, which suggests that the psychosocial dimension of the home environment might be more influential for the formation of cognitive skills than its physical dimension. However, since the level of home goods is affected by market variables and the discrete choices of households, taking into account their effect on the cognitive attainment is vital for assessing the wage and price effects of interest in the next chapter.

In terms of the characteristics correlated with the initial skill endowment girls and children, whose mothers have a high PPVT score, tend to do better in the tests. Higher birth order and lower birth weight are associated with lower scores but the coefficients are not statistically significant. That is in contrast to the results without

unobserved heterogeneity, where having one more older siblings is associated with 1.343 points less on the subtest score. Controlling for selection also decreases the effect of the maternal PPVT score by more than 50%.

6.4 Summary of the results relevant to the assessment of the effect of wage and price changes on early cognitive development

Our empirical analysis of the properties of the production function for cognitive skills shows that the marginal product of both types of paid care quality is positive for almost any amount of non-relative care utilization. The only exception is in the case of a high number of paid home care hours in the last developmental period before the child's entry in kindergarten. Therefore, increasing quality in paid care arrangements has the potential of bringing considerable gains in terms of early cognitive skills.

The marginal product of quantity of paid care in the production of cognitive skills is also positive in most cases, but its magnitude is smaller for care introduced for children in the age group between 43 and 57 months. The negative signs of the coefficients in front of the interaction terms between quality and quantity of non-relative care show that there are technological limits to the beneficial impact of increasing both of those inputs simultaneously. In addition, the presence of a detrimental effect of free home care in all developmental periods suggests that policies, which try to raise children's cognitive skills, should provide incentives to parents to substitute away from this mode of care.

7

The Effect of Wage and Childcare Price Changes on the Cognitive Development of Children with Married Mothers

In this chapter we use the main advantage of our empirical model, i.e., capturing household decisions and the production of cognitive skills in a unified framework, to assess how changes in wage rate and childcare prices impact early development through their effect on the trade-offs parents face when making their childcare choices. While introducing changes in market variables is just one of the tools at the disposal of the government to encourage the early formation of cognitive skills along with childcare regulations or programs providing affordable high quality care such as Head Start, in contrast to most of the other measures, the welfare of the child is not directly specified as their top priority. Tax credits (e.g., the Child Tax Credit and the Dependent Care Tax Credit), and childcare assistance programs (e.g., childcare subsidies to low-income families from the CCDF) are also implemented to increase employment and to reduce welfare dependence among the low-income population which are among the main goals of the Personal Responsibility and Work Opportunity Reconciliation Act (PRWORA) of 1996. In order to incorporate the nature of such

policies, we compute the effects of a variety of wage rate and price changes, where some of them are conditional on particular household decisions (employment or use of a particular type of childcare arrangement).

The specifics of the NICHD SECCYD sample discussed in chapter 4 make it difficult to attach a strong nationwide policy implication to the size of the effects derived from this dataset. Furthermore, the fact that the quasi-structural approach does not account for the way mothers form their expectations about the forcing variables in the model restricts our ability to simulate actual policies. Therefore, we focus instead on the relative differences between all examined effects by looking at how the impact of wage rate and childcare price changes varies across household characteristics, time of occurrence with respect to the life cycle of the child and requirements regarding parental choice of employment and type of care. Such an approach highlights the factors favorable to the success of a potential policy in terms of the cognitive development of the child and provides insights into the design of policies targeting certain parts of the population with respect to the timing and qualifying requirements of such interventions. In this dissertation we limit our analysis to the effects on early cognitive outcomes, although evaluating the effect of wage and childcare prices on children's social behavior outcomes is equally important.

As an example of the potential of the model to capture the variation of the effect of wage rate and childcare price changes on cognitive attainment with respect to the factors above, we focus on married or cohabiting mothers, since the constant presence of another adult in the household and his contribution to the household resources make the trade-offs for those women rather different from the ones faced by single mothers. In order to explore the impact of household characteristics on the wage rate and price effects, the sample of married mothers is divided into five quintiles according to the income of the husbands in the period immediately after the child's birth. The effects of interest are estimated at the means of the household characteristics for

the sample of mothers in the first quintile ("Low income" category), third quintile ("Middle income") and fifth quintile ("High income"). Such an approach allows us to assess the effectiveness of means-tested policies of the analyzed type in the context of early cognitive development. Descriptive statistics of the household variables in each of those categories are reported in table 7.1. Mothers in higher quintiles of their husband's income show weaker preferences toward day care centers, have better education and higher PPVT scores. Mothers in lower quintiles are younger, express more traditional beliefs about childrearing and their children have lower test scores.

Table 7.1: Mean characteristics of the households for the first, third and fifth quintiles of the husband's income immediately after the child's birth

	Low income	Middle income	High income
Preference toward day care center	0.091	0.056	0.051
Preference toward relative care	0.548	0.508	0.390
Black	0.173	0.031	0.015
PPVT score	92.132	101.472	109.236
Traditional Parental Beliefs	64.933	57.169	51.021
Parental locus score	47.635	48.267	47.595
Benefits of work score	19.076	18.667	18.990
Cost of work score	18.959	18.270	17.721
Mother's Education	13.340	14.697	16.128
Mother's Age	26.448	29.916	32.953
Fraction of the period with a partner	0.959	1.000	1.000
Number of other adults in the household	0.199	0.068	0.037
Number of other children in the household	0.920	0.837	0.860
Husband's Income (yearly, in 2000 year thousands)	10.570	37.342	96.498
Woodcock-Johnson subtest scores			
Memory for Sentences	87.085	93.830	98.416
Incomplete Words	93.665	98.028	99.587
Picture Vocabulary	93.655	102.765	107.503
Letter - Word Identification	94.846	100.989	103.854
Applied Problems	97.622	105.399	108.946
Number of observations	197	195	195

Note: Low income group includes married women whose husband's income is in the first quintile; Middle income group includes married women whose husband's income is in the third quintile; High income group includes married women whose husband's income is in the fifth quintile

Table 7.2 shows a description of all wage and price effects changes explored in this study. It is worth noting that the increase in the wage rate is not related to

the characteristics accounting for human capital accumulation and the decrease in the prices is a percentage of the average price faced by all consumers, i.e., it is not specific to the income group. The conditional wage rate and price changes take place only if the household chooses a state which satisfies the particular requirement. We estimate 4 wage rate effects, 2 effects for each type of childcare prices and 2 effects which include simultaneous changes in both kinds of prices[1]. The increase in the wage rate can be related to a tax credit for working mothers with young children resembling the EITC (Earned Income Tax Credit) when applied to employed mothers with a child, while the decrease in the childcare prices for working mothers can give some insight into the effects of the Child and Dependent Care Credit. Decreasing childcare prices for all mothers amounts to providing childcare subsidies for everyone using paid care. Distinguishing between policies affecting prices of different modes of paid care is relevant in the context of the discretionary power of states to use funds from CCDF to contract to purchase slots in day care centers and/or family day care homes, and make those slots available to eligible children[2]. None of the considered changes corresponds to pure income transfer or financial assistance unrelated to the employment status of the mother and her use of paid care mode. That would have required exploring the effect of changes in household income that is different from the mother's labor compensation, but, as we discussed in chapter 4, the measures in NICHD SECCYD associated with those variables are not consistent across the assessments.

While studies like Tekin (2007) evaluate policy options in terms of their cost-effectiveness, i.e., the number of additional hours of work generated for every dollar spent by the government, our reference for measuring the benefits of a certain wage

[1] The effect of an increase in the wage rate only when the mother does not use a paid care arrangement and the effect of price drop only if the mother is not employed are not considered due to their unlikely application in policies.

[2] See Blau (2003) for more details on the relevant legal provisions.

rate or price change is the resulting contribution to the cognitive skills of the child. Therefore, in order to assess the effects of changes in those market variables, we calculate the difference between the expected values of cognitive skills before and after a particular type of change in the wage rate or the prices

$$Eff(\overline{\boldsymbol{\Psi}} \rightarrow \overline{\boldsymbol{\Psi}}') = \mathrm{E}\left[B_{57m}|\overline{\boldsymbol{\Delta}^{Inc}}, \overline{\boldsymbol{\Psi}}', \overline{\boldsymbol{\epsilon}^{f}_{EV}}\right] - \mathrm{E}\left[B_{57m}|\overline{\boldsymbol{\Delta}^{Inc}}, \overline{\boldsymbol{\Psi}}, \overline{\boldsymbol{\epsilon}^{f}_{EV}}\right],$$

where $\overline{\boldsymbol{\Psi}}$ are the wage rates and prices before the change, $\overline{\boldsymbol{\Psi}}'$ are the wage rates and prices after the change, $\overline{\boldsymbol{\Delta}^{Inc}}$ are the mean values of the exogenous characteristics for income group $Inc \in$ {Low income, Middle income, High income} and $\overline{\boldsymbol{\epsilon}^{f}_{EV}}$ are the mean values of the idiosyncratic shocks in the disturbance terms for hours of free home care and free center-based care[3]. The expected values before and after a particular change in the market variables take into account unobserved heterogeneity by integrating out the common factor θ. More details on the derivation and calculation of $Eff(\overline{\boldsymbol{\Psi}} \rightarrow \overline{\boldsymbol{\Psi}}')$ are in appendix H[4].

Our measure of the effect of wage rate and price changes factors in the sign and magnitude of all channels through which their impact on household choices affects cognitive attainment. As our previous findings suggest, it is possible that a certain change can have a positive effect through one characteristic of care but negative through another. For example, a child between the ages of 10 and 18 months who experiences 20 hours of paid center-based care would benefit from a policy which encourages her parents to use more quality and quantity of that mode. However, a

[3] The conditioning on $\overline{\boldsymbol{\epsilon}^{f}_{EV}}$ is a matter of convenience given the fact that no equations related to the discrete use of the free modes of care are estimated and that, as appendix H shows, we do not approximate by simulation, but actually compute the above effects. The computational cost of this approach comes from the necessity to account for all possible combinations of discrete states across the periods (6 states to the power 5 periods = 7776 combinations) at each of the 7 points of the Gauss-Hermite quadrature used for integrating out the unobserved factor θ. Future work will address the issue by simulating the effects of interest.

[4] All other reported effects on subtest scores and parental decisions are defined in a similar way. The only difference is the conditioning set which excludes individual and market variables in future periods.

Table 7.2: Description of wage rate and childcare price changes

LW | PC	Increase in the wage rate with 15% when paid care is used
LW | PHC	Increase in the wage rate with 15% when paid home care is used
LW | PDC	Increase in the wage rate with 15% when center-based care is used
LW	Increase in the wage rate with 15%
PrHC | Em	Decrease in the price of home care with 15% of the average price when mother employed
PrHC	Decrease in the price of home care with 15% of the average price
PrDC | Em	Decrease in the price of day care centers with 15% of the average price when mother employed
PrDC	Decrease in the price of day care centers with 15% of the average price
PrC | Em	Decrease in the price of day care centers and paid home care with 15% of the average prices when mother employed
PrC	Decrease in the price of day care centers and paid home care with 15% of the average prices

price decrease cannot achieve that, since it would lead to a small but still negative change in quality. Similarly, while an increase in the wage rate causes a substitution away from the mode "Work & No paid care", associated with the most hours of the harmful in terms of cognitive development relative care, it also makes households utilize a little less quality of both paid center-based and home care in the cases when those modes are chosen. Another possible negative effect from an increase in the wage rate is that, according to our estimates, mothers might start investing less in an enriching home environment, especially if the change in the market variables is introduced when the child is between 0 and 18 months old.

The estimated total effect also takes into account the fact that changes in market variables continue to affect household decisions regarding childcare attributes beyond the period in which they occur. The findings in chapter 5 suggest that while the use of a paid care arrangement in the previous period increases the number of hours currently spent in either center-based or paid home care, their effect on the quality in those modes is negative in both cases, though small and not statistically significant for the former arrangement. Employment in the previous period has a substantial

effect on the wage rates, which provides yet another channel for a longer lasting effect even from a one-period change in the market variables.

The predicted expected values of the childcare choices and cognitive outcomes for each of the three sets of observable characteristics before the introduction of any wage rate or price change are reported in tables G.5 and G.6 respectively. Although the expected values of the cognitive outcomes are highly non-linear functions of household and market variables, the predicted expected values do not differ substantially from the actual means observed in the relevant subsamples. The predicted expected values are consistently between 1.5 and 2.5 points below the observed means, which in both cases is less than a fifth of the minimal standard deviation for all subtest scores. In that respect it appears that there are no major obstacles for comparing the magnitude of the effects obtained here with the ones discussed in the context of the properties of the production function in chapter 6. A married mother with high income[5] is using less hours of free home care, more hours of paid care, works less, provides a better physical environment for the child and shows a higher level of parenting quality. While lower income usually means lower quality of paid care, significant differences are observed only for paid home care.

The estimates of the wage rate and childcare price changes are presented in table 7.3. For each change and income group, we report the effect in terms of points of cognitive skills, standard deviations in skills and standard deviations of the "Memory for sentences" subtest score. While there are caveats to assessing the quantitative importance of those effects, it is worth comparing them to the impact of changes in the inputs of production, which could be a result of some other type of government intervention (e.g., a program funding the improvement of quality in center-based care). A decrease with 15% in the prices of both types of paid care for working mothers in the

[5] In order to simplify the presentation of the results, from here on we will report the estimates by attributing them to a particular mother possessing the common characteristic for the group.

Table 7.3: Effect of wage rate and price changes on cognitive skills

	Low income				Middle income				High income			
	Change				Change				Change			
	Pts	SD Skill	SD Test	p	Pts	SD Skill	SD Test	p	Pts	SD Skill	SD Test	p
LW | PC	0.735	0.068	0.040	0.000	0.708	0.065	0.038	0.001	0.372	0.034	0.020	0.094
LW | PHC	0.548	0.050	0.030	0.004	0.604	0.056	0.033	0.005	0.384	0.035	0.021	0.067
LW | PDC	0.243	0.022	0.013	0.046	0.158	0.015	0.009	0.247	-0.010	-0.001	-0.001	0.944
LW	0.671	0.062	0.036	0.001	0.717	0.066	0.039	0.001	0.334	0.031	0.018	0.133
PrHC | Em	0.713	0.066	0.039	0.000	0.821	0.076	0.044	0.000	0.707	0.065	0.038	0.000
PrHC	0.719	0.066	0.039	0.000	0.821	0.076	0.044	0.000	0.689	0.063	0.037	0.000
PrDC | Em	0.454	0.042	0.025	0.000	0.411	0.038	0.022	0.004	0.260	0.024	0.014	0.068
PrDC	0.459	0.042	0.025	0.001	0.389	0.036	0.021	0.012	0.210	0.019	0.011	0.203
PrC | Em	1.084	0.100	0.059	0.000	1.125	0.104	0.061	0.000	0.883	0.081	0.048	0.000
PrC	1.092	0.101	0.059	0.000	1.103	0.102	0.060	0.000	0.820	0.076	0.044	0.000

Note: Pts is change in points for skill and subtest "Memory for sentences"; SD Skill is change in standard deviations of the cognitive skill; SD Test is change in standard deviations of the subtest "Memory for sentences"; p is the p-value for the point effect.

middle income group is the change which brings the biggest gain in cognitive skills of 0.104 standard devations. That is smaller than the effect of a one standard deviation increase of the quality of paid center-based care sustained over a one-year period for all three age groups since their effect sizes evaluated at the average hours of care are 0.204 for the age group between 0 to 18 months, 0.158 for the age group between 19 and 42 months and 0.122 for the age group between 43 and 57 months[6]. The most effective price change for the mothers in the low income group is also far from successful in closing the gap between the skill level of their children and the skill level of children with mothers in the middle income groups. A 15% decrease in the price of any type of care brings a 1.092 points rise in the cognitive skills for the low income group which is about a fifth of the difference between the predicted expected values for the two bottom income groups before the price change takes place. The small sizes of the effects suggest that other types of government intervention, discussed in this chapter, might be more successful in improving early cognitive outcomes.

Instead of analyzing the admittedly small quantitative impact of each of the estimated effects[7], in the rest of this chapter we address four issues related to the implications of the relative differences between those effects for government policies utilizing changes in wage rates and childcare prices. Since more than often policy makers have considerations in addition to better cognitive attainment of the children (i.e., fiscal constraints, encouraging employment), our results are valuable for identifying features of such market interventions to which early cognitive development is relatively more sensitive.

[6] A more comprehensive comparison of the effects of changes in market variables with the impact of programs affecting the quality of arrangements at the supply side requires information about the cost of providing this new level of quality and the households' response to this intervention which the NICHD SECCYD dataset does not contain.

[7] Note, though, that in this paper we look only into changes of 15% in the market variables.

7.1 What wage rate and price changes can bring disproportionate gains in the cognitive development of children in low income families?

Our estimates point out that the cognitive skills of children with mother in the low and middle income groups are more sensitive to changes in market variables. For instance, in the case of a wage rate increase unrelated to the use of paid care, the positive effect on cognitive attainment for children in the low income group is twice as big as the one for children in the high income group. The difference is statistically different from zero with a p-value of 0.0039. Similarly, when there is an increase in the wage rate for users of paid center-based care, the effect for the high income group is even negative (though statistically insignificant), while the low income groups still manages to make gains. This is one of the major findings in this study since it implies that means-tested policies exploiting such wage rate and price changes have the potential of being more beneficial for the part of the population where improvements in the cognitive attainment are especially important for better outcomes later in life. While the differences may be small, they are present for each of the analyzed changes, which suggests that creating tax incentives for using paid care are likely to have a bigger impact on aggregate early cognitive attainment when they target families with less resources.

Relative to the other income groups, the gains for the high income subsample are disproportionately smaller when the change is related to the wage rate or the price of center-based care. For instance, while a decrease in the price of home care conditional on employment brings additional 0.713 points in cognitive skills for the low income group and 0.707 points for the high income group, an increase in the wage rate when paid home care is used results in additional 0.548 points for the former group and only 0.384 points for the latter. Furthermore, the difference between the effects of a decrease in the price of center-based care for the low-income group and the high

income group is 0.248 and statistically significant at the 1% level.

In order to provide some insights into why the high income group is less likely to benefit from changes in market variables, we compare in table G.2 the predicted expected values of the chosen childcare attributes for mothers in the middle and high income groups when a wage rate increase of 15% takes place for all women with children between 0 and 57 months. The difference in the effects of 0.383 points in favor of the middle income group is associated with a big average increase[8] in the probability that the mother with high income works – almost 1.5 times bigger than the increase for a mother in the middle income group. As a consequence, mothers with high income are actually using more hours of free home care. The negative consequences from that fact are most pronounced in the last developmental period where the effect of free home care is even stronger for children, whose mothers possess a high quality of parenting skills.

The effects for mothers in the low income group are not always higher in comparison to the ones for mothers in the middle income group. In fact, all changes in wage rates and prices which favor the use of paid home care relative to paid center-based care bring more benefits to the middle income group. The opposite is true for the changes in market variables, which create stronger incentives for the use of paid center-based care. In the case when the prices of both modes of care are decreased simultaneously, there is little difference between the effects for both income groups. For example, a decrease in the prices of center-based care and home care for working mothers brings additional 1.084 and 1.125 points of cognitive skills for the low and middle income groups respectively. In all instances, the differences between the effects are not statistically different from 0 at the 10% level. Therefore, all of the analyzed policies seem to have a similar impact on the two bottom income groups in terms of gains in early cognitve development.

[8] The averaging is across periods.

7.2 Can changes in market variables be more effective in raising cognitive attainment if they target the utilization of a particular type of paid care?

The effects of changes in wage rates and prices, which focus on paid home care, bring more gains for all groups in absolute terms in comparison to those which target center-based care. Even for mothers in the low income group, where the benefits of a price change encouraging the use of day care centers are most substantial, a 15% decrease in the price of home care is associated with an increase in cognitive skills of 0.719 points, while the same price change for center-based care leads to 0.459 additional points.

The comparison of the effects of those changes on the attributes of care in table G.3 shows that while a decrease in the price of center-based care leads to lower quality in both paid modes, a drop in the price of home care has a small positive impact on the quality of paid home care for mothers with low incomes. Furthermore, the effects of price changes in a single decision period reported in table G.1 and the predicted expected values of the childcare characteristics before any change in the market variables show that the positive impact of stimulating the use of a particular mode of paid care is stronger in periods where that type of arrangement is already more prevalent than the other paid setting. While the beneficial effect of a one-period decrease in the price of home care on cognitive outcomes keeps a steady level for all age groups in which it is more frequently observed (i.e., 0 to 30 months), the impact of a decrease in the price of center-based care drops substantially when introduced for children between the ages of 43 and 57 months. The main reason for the last fact is that substantial gains from increasing the intensity of center-based care in the third developmental period in terms of cognitive attainment are realized only when the child is spending more than 35 hours in that arrangement.

The implication of these results is worth emphasizing since they suggest that

market-oriented policies which affect the utilization of paid home arrangements can be more successful than those favoring center-based care due to the more widespread use of paid home care for children between the ages of 0 and 30 months. Even though in the case of low income families the paid home care mode is associated with lower quality[9], the ability of that mode to provide a better environment for cognitive development than relative care makes policies relying on a higher utilization of that type of care worth pursuing. That is in contrast to government programs like Head Start where a substantial and cost effective rise in the quality of care can be achieved mainly in more formal settings such as day care centers.

7.3 How does the conditioning of wage rate and price changes on paid childcare use and employment impact their effect on early cognitive development?

Decreasing the price of day care only when the mother chooses to work does not seem to affect its impact on cognitive skills. This is true for changes in the prices of both center-based or home care regardless of whether those changes take place one at a time or simultaneously. Conditioning the drop of both prices on employment decreases the effect of the price change on cognitive skills for the low income group by only 0.008 points (from 1.092 to 1.084) and even increases the effect for the middle income group by 0.022 (from 1.103 to 1.125). For both income groups the effect on the probability of employment is the same regardless of whether the price changes are conditional on employment, i.e., there is an average increase of 0.041 percentage points for the low income group and 0.04 percentage points for the middle income group. Therefore, we do not find evidence that the work requirement results in an increase of the free home care as a secondary arrangement or a decrease in the home goods that can negate the positive effects of the price changes on cognitive development realized through

[9] Our preliminary analysis showed that low income families are more likely to use family homes, while households with higher incomes use nannies or babysitters

the more intensive utilization of paid care arrangements[10]. That is good news for policies targeting rise in employment levels through lower prices of care since the work requirement does not appear to mitigate their positive effect on early cognitive skills.

We cannot explore the effect of the work requirement through the changes in the wage rate since we are not assessing the reference point – increase in the income of the household regardless of the employment status of the mother. Instead, we reverse the question and look into whether not conditioning the increase of the wage rate on the use of a paid care arrangement could affect negatively the impact of that increase on cognitive attainment. Table G.4 shows that for the low income group conditioning the change of the wage rate on the use of a paid care arrangement brings down the hours of free home care by additional 0.097 hours on average. Furthermore, the lack of requirement for utilization of paid care decreases the measure of home goods by 0.007 on average, while the same drop associated with a wage rate increase in the presence of such a requirement is only 0.001. While those numbers might look pretty small, they seem to explain why the effect of a wage rate increase only when the mother uses paid care is 9.5% bigger than the effect on cognitive skills of a wage rate increase without that condition for mothers in the low income group. This difference, however, is not statistically different from 0 even at the 10% level. The children of the women in the same group are also the ones who benefit the most from such a requirement, since their peers with mothers in the middle income group do not appear to be gaining anything from it. The results from the effects of wage rate increases which take place only in a singular period suggest that the requirement has the biggest effect when applied from 0 to 9 months after the child's birth.

Raising the wage rate for all working mothers in the low income group leads to

[10] This observation is confirmed by direct comparison of the effect on those attributes for both types of price changes. For example, the measure of home goods increases on average by 0.3 with and without a work requirement for the low income group when both prices change.

an average increase in employment probability of 0.054, while the increase in the case of a paid care requirement is 0.051. The magnitude of these statistically insignificant differences suggest that if a raise in the employment levels is the main priority of a policy affecting the wage rates of mothers, the additional beneficial effect of a paid care use requirement on cognitive skills is not substantial enough to justify the introduction of such a requirement.

7.4 Does the timing of the change in a market variable with respect to the life cycle of the child matter for its effect on early cognitive attainment?

A change in the mother's wage rate or cost of using paid care arrangements closer to the child's birth can be more beneficial for early cognitive attainment if those earlier developmental periods are more sensitive for the acquisition of skills, the mother is more willing to use more effective childcare attributes in the current decision period as a result of the price change and/or the effect of those changes on earlier household choices translates into formation of habits of work and paid care use that result in future childcare decisions affecting cognitive attainment in a positive way. Table G.1 reports the effects of changes in the wage rate and childcare prices in a singular decision period for each pair of the 10 analyzed changes. The main conclusion from those results is that interventions based on market variables in the last developmental period are not likely to be successful in terms of raising the cognitive attainment of children, since there are no positive statistically significant effects on cognitive development for any of the assessed changes.

The comparison of the effects for the first two developmental periods shows magnitudes which are quite similar, despite the more limited ability of wage rate and childcare price changes in the second developmental period to affect future childcare choices. For the low income group an increase in the wage rate for a mother with a

child less than 18 months old results in an average[11] gain of 0.18 points in cognitive skills, while the average effect from a wage rate increase when the child is between 19 and 42 months old is additional 0.17 points. In the middle income group the positive effects of a wage rate change in the first developmental period are more pronounced since at 0.27 points they are almost twice the size of the effects relates to changes in the second developmental period. In the case of a decrease in the childcare prices we observe the opposite situation, e.g., for the low income group the average effect of such a change on cognitive attainment is 0.291 points when the change is introduced in the second developmental period, which is 0.059 points more than the average effect of the same change introduced in the first developmental period.

One of the reasons why the third developmental period is so different from the other ones in terms of the effect of the changes in wage rates and prices on cognitive skills has to do with the lower marginal product of hours of care evaluated at the mean intensity for the particular period. In fact, an additional hour of paid care brings a gain in the cognitive skills only for low qualities of paid home care and high quantities of paid center-based care. Therefore, the only way to affect positively cognitive attainment through measures in this developmental period is to increase the quality of care. However, as we have already shown in chapter 5, an increase in the wage rate or a decrease in the price of care are not capable of achieving such an effect. Since at that age the majority of the children (58%) are in paid center-based care, the fact that parents do not perceive quality and quanity of care as complementary goods puts serious limitations on any policy designed to improve cognitive development through change in wage rates or prices in that period. As a consequence of that, government programs for children in this age group should put emphasis on a rise in the quality of care which does not rely on parental responses to market stimuli. An obvious choice in this respect are programs such as Head Start.

[11] The average is on yearly basis for the two decision periods inside the developmental period.

8

Conclusions

This dissertation uses the data from the NICHD SECCYD to evaluate features of wage and childcare price changes that are associated with positive effects on children's early cognitive skills. Identifying beneficial characteristics of changes in market variables is especially relevant in a policy environment where the main priority of tax incentives related to the use of childcare is not facilitating the formation of children's cognitive skills, but reducing reliance on the welfare system through an increase in employment among poor households.

Our empirical approach handles selection issues arising from systematic placing of certain types of children in childcare arrangements of particular type and quality by utilizing a unified estimation framework for household choices of childcare characteristics and production function for cognitive skills, which is founded on a clearly specified theoretical model that captures a rich set of childcare alternatives. We estimate jointly the discrete household choices related to the employment status of the mother and the use of a paid care mode, the demand functions for quantity and quality of childcare characteristics, the production function for cognitive outcomes, the wage process for the mother, and the childcare price equations based on the hedonic

pricing method, while at the same time introducing unobserved heterogeneity in the disturbance terms of all estimated outcomes. Our strategy of handling selection problems also utilizes the exogenous variation in childcare prices across the 10 geographic markets for childcare services defined by the study sites in the NICHD SECCYD dataset, which in our model influence choices, but do not affect cognitive outcomes directly.

Our results show that controlling for unobserved characteristics is important for assessing both the effect of wage and prices on childcare choices and the properties of the production function for skills. Controlling for selection tends to increase the magnitude and statistical significance of almost all considered effects. Therefore, failing to account for common unobservables results in underestimates of the impact of all wage and price changes evaluated in our study. This finding also raises question about the reliability of some of the results in the early studies analyzing the NICHD SECCYD dataset, which put little emphasis on controlling for selection in their empirical approaches[1].

The estimates of the parents' substitution behavior across types of care show that prices and wages do affect the decisions related to the use of a particular mode of paid care and the number of hours the child spends there, although they do not have a statistically significant impact on the quality of paid care. This finding points out the main challenge faced by a policy utilizing changes in wages and prices to affect early cognitive skill formation, i.e., regardless of their magnitude, the only way such changes can be beneficial is through their impact on the intensity of non-maternal care use alone.

The parameters of the production function for cognitive skills show that, indeed, by not being able to influence quality of paid care, wage and price changes lose an important channel to affect early cognitive outcomes. The marginal product of both

[1] This issue is discussed in chapter 2.

types of paid care quality is positive for any level of non-relative care utilization, with the exception of a very high intensity of paid home care use in the last developmental period before the child's entry in kindergarten. Still, wage and price changes have the potential of improving school-readiness, since the additional hours of paid care are in most cases associated with gains in the cognitive skills, although the magnitude of those gains is substantially lower when the quantity of care increases for children older than 3 years and a half. The negative effect of free home care in all periods, combined with the fact that working mothers, and especially those who do not use paid care arrangements, leave their children for longer periods in such arrangements, suggests that we cannot ignore the possibility that in some cases providing incentives for mothers to work might have negative effect on children's cognitive outcomes.

Our comparison of the wage and price effects for three sets of values of the observable household characteristics representing low, middle and high income household shows that: (1) a tax credit for working mothers in the spirit of EITC and childcare subsidies for center-based care can bring disproportionate gains in cognitive development to low and middle income groups, but none of the analyzed policies favor low income families in particular; (2) subsidizing paid home care for children less than 3 and a half years old can be more effective than subsidizing center-based care for the same age group in terms of improving cognitive outcomes at the age of 5; (3) conditioning childcare assistance for paid care on the employment status of the mother does not seem to have a strong negative effect on skill formation; and (4) tax incentives affecting wage rates and childcare prices prove to be useful for the formation of early cognitive skills only when they are implemented while the child is less than 3 and a half years old.

There are, however, certain qualifications to the results of this study. NICHD SECCYD is not a nationally representative study and its early phases analyzed here were conducted in the first half of the 1990s – a period prior to the passing PWRORA

in 1996 which is the the bill with the most substantial impact on current US policy environment in this area. Furthermore, while in 1993 21.6% of the households report the use of other non-relative care[2], this number drops to 12.9% in 2011 (Laughlin, 2013)[3], which suggests that policies targeting the use of paid home care might be less successful nowadays. This is a very difficult problem to solve given that the only more recent study which contains the necessary variables for an analysis such as ours is ECLS-K.

The size of our sample also does not allow the estimation of separate models for single and married mothers[4], which would entail dropping altogether observations for children whose mothers were single during one part of NICHD SECCYD and living with a partner during another part. Duncan and NICHD (2003) also point out that since few children were observed in low-quality settings, that hinders the assessment of improving such settings and could lead to underestimating the effect of quality on cognitive outcomes.

Future work will try to relax some of the main assumptions adopted in this paper. While allowing the precise number of hours the child spends in non-maternal care to affect the quality of the home environment is problematic due to the lack of data describing how the mother spends her hours outside of work[5], introducing a richer structure for the unobserved heterogeneity, in which there is a new factor originating in each decision or developmental period, is straightforward given the capabilities of

[2] Our definition of paid home care is very close to the one for other non-relative care used in Laughlin (2013).

[3] Note, though, that there does not appear to be a shift toward day care centers, since for that period there is also a drop in the families reporting use of organized facilites, i.e., from 29.9% in 1993 to 25.2% in 2011.

[4] Studies such as Blau (2003) emphasize that the decisions of single and married mothers are affected by different factors.

[5] The only data in NICHD SECCYD on that matter are several questions related to the time parents spend with their child in HOME index and the information from the time use survey for the mother when the child was 7 months old.

the software developed for this project[6]. Furthermore, estimating additional equations for cognitive skills at earlier ages and making subsequent parental decisions dependent on a function of those measures[7] can introduce a channel through which past childcare decisions are no longer irrelevant to current choices. Lastly, we can address the robustness of the model specification by relaxing to some degree the assumption of no missing inputs in the production function of cognitive attainment.

Our empirical model, the NICHD SECCYD dataset and the designed estimation routine are capable of exploring a wide variety of topics related to early formation of skills. Future work will focus on the effect of wage and price changes of non-cognitive skills, which studies like Cunha and Heckman (2008) identify as another major determinant of later life outcomes. That will allow us to assess the overall impact of tax policies implemented in early childhood on subsequent outcomes associated with adolescent risky behavior – drugs, alcohol and cigarette use, sexual activity and crime.

[6] Our software can handle multiple factors which can have a normal or discrete distribution, as well as a finite mixture of normal distributions.

[7] The exact functional form depends on the assumptions with respect to the way parents form their beliefs about the abilities of their children.

Appendix A

Variable Description and Exclusion Restrictions

Table A.1: Description of variables in the empirical specification

Variable	Description
t_{0-9m}	Dummy variable for the decision period in which the child is between 0 and 9 months old
t_{10-18}	Dummy variable for the decision period in which the child is between 10 and 18 months old
t_{19-30}	Dummy variable for the decision period in which the child is between 19 and 30 months old
t_{31-42}	Dummy variable for the decision period in which the child is between 31 and 42 months old
t_{43-57}	Dummy variable for the decision period in which the child is between 43 and 57 months old
MEduc	Years of maternal education
MAge	Mother's age
MAge^2	Mother's age squared
Infant<6m	Presence of an infant less than 6 months old in the household
MPRFDC	Maternal preference toward day care centers
MPRFRL	Maternal preference toward relative care
MBLACK	Mother African American
CSex	Sex of the child
MPPVT	Mother's Peabody Picture Vocabulary Test score
MPartTime	Mother working part-time prior to birth
MFullTime	Mother working full-time prior to birth
MTRAD	Mother's traditional beliefs about child-rearing
MPLOC	Mother's parental locus of control score
MBenWk	Mother's perceived benefits from employment

Variable	Description
MCstWk	Mother's perceived costs of working
ChiSup	Mother receives child support
HINC	Number of types of income the household receives from savings, rental property and other investments
FINC	Average monthly income of the husband/partner when he lives with the mother (in hundreds)
MPrWork	Working status of the mother in the previous period
PrPaidCare	Any paid care or free day care center for more than 15 hours a week in the previous period
MwHusb	Fraction of the period in which the mother lives with a husband/partner
NAdult	Number of adults in the household in addition to the parents
NChild	Number of other children in the household
RATDC	Children-to-staff day care center state requirement
SIZEDC	Group size (number of children) day care center state requirement
ESIZEDC	Group size (number of children) day care center state requirement present
RATFH	Children-to-staff family home state requirement
SIZEFH	Group size (number of children) family home center state requirement
CCDF	Child care development fund state-level expenditures per capita
NDC1000	Number of day care establishments per 1000 children in the state
Site1	Study site 1
Site2	Study site 2
Site3	Study site 3
Site4	Study site 4
Site5	Study site 5
Site6	Study site 6
Site7	Study site 7
Site8	Study site 8
Site9	Study site 9
Site9	Study site 10
CBord	Child's birth order
CBWtg	Child's birth weight in kilograms
LWage (w^*)	Logarithm of the mother's hourly wage rate
PriceDC (p_d^*)	Price of day care centers
PriceHC (p_h^*)	Price of home care
Work	Employment status
PaidHC	Use of paid home care
PaidDC	Use of paid day care center
$F^p_{0-9m,d}$	Hours of paid day care center per week for ages 0 to 9 months
$F^f_{0-9m,d}$	Hours of free day care center per week for ages 0 to 9 months
$F^p_{0-9m,h}$	Hours of paid home care per week for ages 0 to 9 months
$F^f_{0-9m,h}$	Hours of free home care per week for ages 0 to 9 months
$F^p_{10-18m,d}$	Hours of paid day care center per week for ages 10 to 18 months

Variable	Description
$F^f_{10-18m,d}$	Hours of free day care center per week for ages 10 to 18 months
$F^p_{10-18m,h}$	Hours of paid home care per week for ages 10 to 18 months
$F^f_{10-18m,h}$	Hours of free home care per week for ages 10 to 18 months
$F^p_{19-30m,d}$	Hours of paid day care center per week for ages 19 to 30 months
$F^f_{19-30m,d}$	Hours of free day care center per week for ages 19 to 30 months
$F^p_{19-30m,h}$	Hours of paid home care per week for ages 19 to 30 months
$F^f_{19-30m,h}$	Hours of free home care per week for ages 19 to 30 months
$F^p_{31-42m,d}$	Hours of paid day care center per week for ages 31 to 42 months
$F^f_{31-42m,d}$	Hours of free day care center per week for ages 31 to 42 months
$F^p_{31-42m,h}$	Hours of paid home care per week for ages 31 to 42 months
$F^f_{31-42m,h}$	Hours of free home care per week for ages 31 to 42 months
$F^p_{43-57m,d}$	Hours of paid day care center per week for ages 43 to 57 months
$F^f_{43-57m,d}$	Hours of free day care center per week for ages 43 to 57 months
$F^p_{43-57m,h}$	Hours of paid home care per week for ages 43 to 57 months
$F^f_{43-57m,h}$	Hours of free home care per week for ages 43 to 57 months
Q_m	Latent quality of parenting measured by the HOME inventory
$Q^p_{0-9m,d}$	Quality of paid day care center per week for ages 0 to 9 months
$Q^p_{0-9m,h}$	Quality of paid home care per week for ages 0 to 9 months
$Q^f_{0-9m,d}$	Quality of free day care center per week for ages 0 to 9 months
$Q^p_{10-18m,d}$	Quality of paid day care center per week for ages 10 to 18 months
$Q^p_{10-18m,h}$	Quality of paid home care per week for ages 10 to 18 months
$Q^f_{10-18m,d}$	Quality of free day care center per week for ages 10 to 18 months
$Q^p_{19-30m,d}$	Quality of paid day care center per week for ages 19 to 30 months
$Q^p_{19-30m,h}$	Quality of paid home care per week for ages 19 to 30 months
$Q^f_{19-30m,d}$	Quality of free day care center per week for ages 19 to 30 months
$Q^p_{31-42m,d}$	Quality of paid day care center per week for ages 31 to 42 months
$Q^p_{31-42m,h}$	Quality of paid home care per week for ages 31 to 42 months
$Q^f_{31-42m,d}$	Quality of free day care center per week for ages 31 to 42 months
$Q^p_{43-57m,d}$	Quality of paid day care center per week for ages 43 to 57 months
$Q^p_{43-57m,h}$	Quality of paid home care per week for ages 43 to 57 months
$Q^f_{43-57m,d}$	Quality of free day care center per week for ages 43 to 57 months
E_{0-9m}	Measure of development-enhancing goods for ages 0 to 9 months from the HOME inventory
E_{10-18m}	Measure of development-enhancing goods for ages 10 to 18 months from the HOME inventory
E_{19-30m}	Measure of development-enhancing goods for ages 19 to 30 months from the HOME inventory
E_{31-42m}	Measure of development-enhancing goods for ages 31 to 42 months from the HOME inventory
E_{43-57m}	Measure of development-enhancing goods for ages 43 to 57 months from the HOME inventory
$K^p_{0-9m,d}$	Indicator if paid day care center is used for ages 0 to 9 months

Variable	Description
$K^p_{0-9m,h}$	Indicator if paid home care is used for ages 0 to 9 months
$K^f_{0-9m,d}$	Indicator if free day care center is used for ages 0 to 9 months
$K^p_{10-18m,d}$	Indicator if paid day care center is used for ages 10 to 18 months
$K^p_{10-18m,h}$	Indicator if paid home care is used for ages 10 to 18 months
$K^f_{10-18m,d}$	Indicator if free day care center is used for ages 10 to 18 months
$K^p_{19-30m,d}$	Indicator if paid day care center is used for ages 19 to 30 months
$K^p_{19-30m,h}$	Indicator if paid home care is used for ages 19 to 30 months
$K^f_{19-30m,d}$	Indicator if free day care center is used for ages 19 to 30 months
$K^p_{31-42m,d}$	Indicator if paid day care center is used for ages 31 to 42 months
$K^p_{31-42m,h}$	Indicator if paid home care is used for ages 31 to 42 months
$K^f_{31-42m,d}$	Indicator if free day care center is used for ages 31 to 42 months
$K^p_{43-57m,d}$	Indicator if paid day care center is used for ages 43 to 57 months
$K^p_{43-57m,h}$	Indicator if paid home care is used for ages 43 to 57 months
$K^f_{43-57m,d}$	Indicator if free day care center is used for ages 43 to 57 months
$C^{Q_m}_{0-9m}$	Measure of parenting quality from the HOME inventory for ages 0 to 9 months
$C^{Q_m}_{10-18m}$	Measure of parenting quality from the HOME inventory for ages 10 to 18 months
$C^{Q_m}_{31-42m}$	Measure of parenting quality from the HOME inventory for ages 31 to 42 months
$C^{Q_m}_{43-57m}$	Measure of parenting quality from the HOME inventory for ages 43 to 57 months
C^B_{WJMS}	Woodcock-Johnson Psycho Educational Battery (Revised): Memory for sentences score
C^B_{WJAP}	Woodcock-Johnson Psycho Educational Battery (Revised): Applied Problems score
C^B_{WJPV}	Woodcock-Johnson Psycho Educational Battery (Revised): Picture Vocabulary score
C^B_{WJIW}	Woodcock-Johnson Psycho Educational Battery (Revised): Incomplete Words score
C^B_{WJLW}	Woodcock-Johnson Psycho Educational Battery (Revised): Letter-Word Identification score

Table A.2: Exclusion restrictions in the model

Variable	Wage	Prices of care	Decision Rules	Quality of Parenting	Cognitive skill
t_{10-18}	X	X	X		
t_{19-30}	X	X	X		
t_{31-42}	X	X	X		
t_{43-57}	X	X	X		
MEduc	X	X	X	X	
MAge	X	X	X	X	

Variable	Wage	Prices of care	Decision Rules	Quality of Parenting	Cognitive skill
$MAge^2$	X				
Infant<6m		X	X		
MPRFDC		X	X	X	
MPRFRL		X	X	X	
MBLACK		X	X	X	
CSex		X	X		X
MPPVT		X	X	X	X
MPartTime	X				
MFullTime	X				
MTRAD		X	X	X	
MPLOC		X	X	X	
MBenWk		X	X	X	
MCstWk		X	X	X	
ChiSup		X	X		
HINC		X	X		
FINC		X	X		
MPrWork	X	X	X		
PrPaidCare		X	X		
MwHusb		X	X	X	
NAdult		X	X	X	
NChild		X	X	X	
RATDC		X	X		
SIZEDC		X	X		
ESIZEDC		X	X		
RATFH		X	X		
SIZEFH		X	X		
CCDF		X	X		
NDC1000		X	X		
Site1	X	X			
Site2	X	X			
Site3	X	X			
Site4	X	X			
Site5	X	X			
Site6	X	X			
Site7	X	X			
Site8	X	X			
Site9	X	X			
CBord		X	X		X
CBWtg		X	X		X
LWage (w^*)			X		
PriceDC (p_d^*)			X		
PriceHC (p_h^*)			X		
Work			X		

Variable	Wage	Prices of care	Decision Rules	Quality of Parenting	Cognitive skill
PaidHC			X		
PaidDC			X		
$F^p_{0-9m,d}$					X
$F^f_{0-9m,d}$					X
$F^p_{0-9m,h}$					X
$F^f_{0-9m,h}$					X
$F^p_{10-18m,d}$					X
$F^f_{10-18m,d}$					X
$F^p_{10-18m,h}$					X
$F^f_{10-18m,h}$					X
$F^p_{19-30m,d}$					X
$F^f_{19-30m,d}$					X
$F^p_{19-30m,h}$					X
$F^f_{19-30m,h}$					X
$F^p_{31-42m,d}$					X
$F^f_{31-42m,d}$					X
$F^p_{31-42m,h}$					X
$F^f_{31-42m,h}$					X
$F^p_{43-57m,d}$					X
$F^f_{43-57m,d}$					X
$F^p_{43-57m,h}$					X
$F^f_{43-57m,h}$					X
Q_m					X
$Q^p_{0-9m,d}$					X
$Q^p_{0-9m,h}$					X
$Q^f_{0-9m,d}$					X
$Q^p_{10-18m,d}$					X
$Q^p_{10-18m,h}$					X
$Q^f_{10-18m,d}$					X
$Q^p_{19-30m,d}$					X
$Q^p_{19-30m,h}$					X
$Q^f_{19-30m,d}$					X
$Q^p_{31-42m,d}$					X
$Q^p_{31-42m,h}$					X
$Q^f_{31-42m,d}$					X
$Q^p_{43-57m,d}$					X
$Q^p_{43-57m,h}$					X
$Q^f_{43-57m,d}$					X
E_{0-9m}					X

Variable	Wage	Prices of care	Decision Rules	Quality of Parenting	Cognitive skill
E_{10-18m}					X
E_{19-30m}					X
E_{31-42m}					X
E_{43-57m}					X
$K^p_{0-9m,d}$					X
$K^p_{0-9m,h}$					X
$K^f_{0-9m,d}$					X
$K^p_{10-18m,d}$					X
$K^p_{10-18m,h}$					X
$K^f_{10-18m,d}$					X
$K^p_{19-30m,d}$					X
$K^p_{19-30m,h}$					X
$K^f_{19-30m,d}$					X
$K^p_{31-42m,d}$					X
$K^p_{31-42m,h}$					X
$K^f_{31-42m,d}$					X
$K^p_{43-57m,d}$					X
$K^p_{43-57m,h}$					X
$K^f_{43-57m,d}$					X

Notes:
(1) The variables determining quality of parenting are set to their values at the child's birth.
(2) The interaction terms are not included in this table.

Appendix B

Imputation of Payment Status

In order to predict the payment status of arrangements which took place between major assessment points, we divide them into three categories: day care center, family home care and babysitters (and nannies). The latter two categories form the home care mode which we introduced in the main analysis. The difference between them is that unlike babysitting arrangements, family home care does not take place in the child's home. This further distinction takes into account that the place of care is likely to matter for the payment status of the arrangement associated with it. We estimate a separate probit model for each of those categories using household demographics, characteristics of the arrangements, such as adult-to-children ratio, variables related to the history of the use of this arrangement by the child, and the study site dummies. The dependent variable equals 1 if the arrangement is paid and 0 otherwise. The exact specification of the probit models and the estimated results can be found in tables B.2, B.3 and B.4.

Based on the estimates from the probit models we predict the probabilities of being paid for each arrangement. If the predicted probability exceeds 0.735 for a particular setting, we determine that it is a associated with a non-zero payment. We do not use the standard threshold of 0.5 since it leads to a large number of free arrangements wrongly categorized

as paid. Our cutoff probability is the one closest to that standard value, which at the same time ensures that more than 50% of the settings with non-missing payment status were correctly predicted in each of the three modes[1]. The final imputation results are shown in table B.1 where we cross-tabulate predicted and actual statuses. It appears that the predicted proportion of free arrangements is larger for settings with missing payment status but that fact could be attributed to the specific nature of those arrangements (i.e., they are used for a shorter period of time by the households).

Table B.1: Predicted and actual payment status of non-relative care

	Actual free	Actual paid	Missing	All
Day care centers				
Predicted free	175	174	89	438
Predicted paid	128	1,712	203	2043
All	303	1886	292	2481
Family Homes				
Predicted free	59	74	124	257
Predicted paid	55	1,387	269	1711
All	114	1461	393	1968
Babysitters				
Predicted free	24	27	64	115
Predicted paid	17	510	233	760
All	41	537	297	875

[1] In his discussion of the issue, Greene (2000) points out that changing the threshold is always associated with an increase in the correct classifications for one of the categories and an increase in the incorrect classifications for the other. Therefore, the choice of threshold depends to a considerable extent on the setting. For example, faced with similar issues when imputing childcare choices for the mothers in their study, Bernal and Keane (2010) chose a threshold of 0.65 "to obtain a smooth trend of childcare use".

Table B.2: Probit to predict payment status of day care centers

Variable	Coefficient	St. error
Constant	-0.6152	0.5118
t_{10-18m}	-0.2917	0.3036
t_{19-30m}	-0.5168	0.2863
t_{31-42m}	-0.4398	0.2916
t_{43-57m}	-0.6792	0.3133
Adult-to-children ratio	-1.6788	0.5342
Group size	-0.0085	0.0105
Arrangements with reported group size > 25	0.3644	0.2596
Hours in day care center	0.0138	0.0040
Age when day care center was first used	0.0011	0.0040
Age of the child when arrangement began	-0.0054	0.0058
MwHusb	-0.3577	0.1851
Number of children which the overall fee covers	-0.1050	0.0815
MPRFDC	-0.3622	0.1388
MPRFRL	-0.1944	0.0887
Partner's labor supply (hours a week)	0.0244	0.0034
Mother's labor supply (hours a week)	0.0129	0.0028
MBLACK	-0.5506	0.1241
Mother hispanic	0.3334	0.2437
MWduc	0.1614	0.0215
Infant<6m	-0.1600	0.2913
NAdult	-0.0273	0.0829
NChild	-0.1826	0.0465
Site0	-0.4390	0.1867
Site1	-0.4045	0.1971
Site2	-0.4198	0.1928
Site3	-0.2543	0.1970
Site4	0.0263	0.2034
Site5	0.1382	0.2076
Site6	-0.1679	0.2057
Site7	-0.0319	0.1987
Site8	-0.1935	0.1940
Number of arrangements = 2189		
Log likelihood function = -632.3187		

Table B.3: Probit to predict payment status of family home care

Variable	Coefficient	St. error
Constant	-1.3245	0.7061
t_{10-18m}	0.2025	0.3613
t_{19-30m}	0.1375	0.3468
t_{31-42m}	0.3966	0.3727
t_{43-57m}	0.5305	0.4274
Adult-to-children ratio	-0.3712	0.2213
Group size	-0.0371	0.0215
Hours in family home care	0.0369	0.0060
Age when family home care was first used	0.0088	0.0076
Age of the child when arrangement began	-0.0175	0.0089
MwHusb	0.1555	0.3009
Number of children which the overall fee covers	-0.3460	0.1403
MPRFDC	-0.4686	0.2789
MPRFRL	0.0590	0.1287
Partner's labor supply (hours a week)	0.0124	0.0057
Mother's labor supply (hours a week)	0.0277	0.0051
MBLACK	0.0087	0.2265
Mother hispanic	0.3954	0.3920
Meduc	0.0970	0.0332
Infant<6m	0.6578	0.4896
Nadult	0.3092	0.1707
Nchild	-0.0302	0.1011
Site0	-0.1340	0.3619
Site1	-0.1933	0.2800
Site2	-0.1250	0.2683
Site3	-0.5478	0.2768
Site4	0.0734	0.3640
Site5	0.0979	0.3681
Site6	-0.4549	0.2786
Site7	-0.4642	0.2608
Site8	-0.6381	0.3003
Number of arrangements = 1575		
Log likelihood function = -276.2878		

Table B.4: Probit to predict payment status of babysitter arrangements

Variable	Coefficient	St. error
Constant	-4.8464	1.2618
t_{10-18m}	-0.1554	0.7188
t_{19-30m}	0.2549	0.7667
t_{31-42m}	0.0256	0.8421
t_{43-57m}	-0.1829	0.9454
Hours with a babysitter	0.0765	0.0166
Age when babysiiter was first used	-0.0104	0.0131
Age of the child when arrangement began	0.0028	0.0186
MwHusb	2.2960	0.6490
Number of children which the overall fee covers	0.1183	0.2611
MPRFDC	0.4667	0.6743
MPRFRL	0.0591	0.2585
Partner's labor supply (hours a week)	-0.0140	0.0104
Mother's labor supply (hours a week)	-0.0113	0.0100
MBLACK	0.5855	0.5682
Mother hispanic	-0.1833	0.6188
Meduc	0.2500	0.0677
Infant<6m	-0.6711	0.9634
Nadult	0.3777	0.4084
Nchild	0.2954	0.2116
Site0	-0.1722	0.7121
Site1	0.3317	0.5959
Site2	0.5541	0.5832
Site3	1.0830	0.6429
Site4	-0.0998	0.5378
Site6	0.8667	0.7633
Site7	-0.8332	0.5438
Site8	-0.2344	0.5778
Number of arrangements = 567		
Log likelihood function = -79.193664		

Appendix C

Descriptive Statistics Tables

Table C.1: Use of childcare arrangements by age groups

	0 to 9 m.		10 to 18 m.		19 to 30 m.		31 to 42 m.		43 to 57 m.	
	Obs.	%	Obs.	%	Obs.	%	Obs.	%	Obs.	%
Work & Paid day care center	131	9.98	168	13.13	238	19.03	399	32.36	511	45.99
Work & Paid home care	433	32.98	450	35.16	414	33.09	339	27.49	209	18.81
Work & No paid care	360	27.42	351	27.42	325	25.98	225	18.25	172	15.48
No work & Paid day care center	22	1.68	25	1.95	49	3.92	105	8.52	132	11.88
No Work & Paid Home Care	42	3.2	40	3.12	37	2.96	28	2.27	11	0.99
No work & No paid care	325	24.75	246	19.22	188	15.03	137	11.11	76	6.84
All	1313	100	1280	100	1251	100	1233	100	1111	100

Table C.2: Descriptive statistics of time-varying variables by age groups

	0 to 9 m.		10 to 18 m.		19 to 30 m.		31 to 42 m.		43 to 57 m.	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Logarithm of the mother's wage rate	2.68	0.69	2.61	0.66	2.60	0.66	2.65	0.64	2.59	0.68
Price of day care center	2.83	1.28	2.85	1.29	2.69	1.20	2.74	1.20	2.87	1.18
Price of home care	2.53	1.31	2.61	1.26	2.49	1.15	2.54	1.22	2.51	1.25
Mother working	0.70	0.21	0.76	0.18	0.78	0.17	0.78	0.17	0.80	0.16
Paid day care center used	0.12	0.10	0.15	0.13	0.23	0.18	0.41	0.24	0.58	0.24
Paid home care used	0.36	0.23	0.38	0.24	0.36	0.23	0.30	0.21	0.20	0.16
Hours of paid day care center	2.40	8.07	3.64	10.68	5.49	12.86	8.82	15.08	11.81	15.42
Hours of paid day care center for user	20.61	13.56	24.14	16.19	23.93	16.74	21.59	16.75	20.40	15.34
Hours of paid home care	7.20	12.62	9.58	15.60	9.23	15.52	7.88	14.89	5.51	12.95
Hours of paid home care for users	19.91	13.69	25.02	15.79	25.60	15.77	26.47	15.91	27.81	15.09
Hours of free day care centers	0.13	2.02	0.35	3.37	0.49	3.85	0.80	4.39	2.29	7.27
Hours of free day care center for users	19.63	15.47	23.40	15.45	20.55	14.56	15.50	12.08	17.55	11.72
Hours of free home care	7.20	12.62	9.58	15.60	9.23	15.52	7.88	14.89	5.51	12.95
Hours of free home care for users	19.91	13.69	25.02	15.79	25.60	15.77	26.47	15.91	27.81	15.09
Quality of paid day care center	2.70	0.53	2.63	0.53	2.60	0.48	2.75	0.45	3.03	0.56
Quality of paid home care	2.90	0.60	2.92	0.58	2.89	0.56	2.87	0.47	2.98	0.57
Quality of free day care center	2.61	0.71	2.67	0.59	2.57	0.45	2.71	0.41	2.05	0.56

Table C.3: Descriptive statistics of household characteristics at the time of the child's birth

Variable	Mean	SD
Maternal preference toward day care centers	0.08	0.28
Maternal preference toward relative care	0.50	0.50
Mother African American	0.12	0.33
Sex of the child	0.52	0.50
Mother's Peabody Picture Vocabulary Test score	99.01	17.30
Mother's traditional beliefs about child-rearing	60.14	15.06
Mother's parental locus of control score	47.82	7.54
Mother's perceived benefits from employment	19.18	3.16
Birth weight of the child in kilograms	3.49	0.50
Mother's perceived costs of working	18.33	5.24
Mother receives child support	0.08	0.27
Number of incomes from investment	0.33	0.57
Monthly income of the husband/partner (thousands)	3.17	3.08
Mother's years of education	14.27	2.51
Mother's age	28.82	5.66
Mother married	0.86	0.34
Number of other adults in the household	0.23	0.64
Number of other children in the household	0.92	1.04
Mother working part-time prior to birth	0.11	0.31
Mother working full-time prior to birth	0.72	0.45
Child's birth order	1.82	0.93

Table C.4: Descriptive statistics of measures of cognitive development and parenting quality

Measure	Obs.	Mean	SD
Quality of parenting measure (HOME, age 6 months)	1313	22.33	3.39
Quality of parenting measure (HOME, age 15 months)	1280	22.03	3.76
Quality of parenting measure (HOME, age 36 months)	1233	24.06	6.36
Quality of parenting measure (HOME, age 54 months)	1111	25.79	3.95
Woodcock-Johnson: Memory for sentences score	1049	91.73	18.47
Woodcock-Johnson: Incomplete Words score	1045	96.66	13.64
Woodcock-Johnson: Picture Vocabulary score	1055	100.27	15.04
Woodcock-Johnson: Letter-Word Identincation score	1051	98.94	13.54
Woodcock-Johnson: Applied Problems score	1048	102.96	15.64

Appendix D

Additional Results for Household Decisions

Table D.1: Estimation results for the price equations

	Unobserved heterogeneity		No unobserved heterogeneity	
	Price day care centers	Price home care	Price day care centers	Price home care
Variables				
Constant	0.721	2.203***	0.385	1.975***
t_{10-18}	-0.4*	0.037	-0.233	0.04
t_{19-30}	-0.827***	-0.033	-0.556***	-0.081
t_{31-42}	-1.057***	-0.008	-0.745***	-0.063
t_{43-57}	-1.44***	-0.424	-1.095***	-0.479*
MPRFDC	-0.121	0.277**	-0.126	0.237*
MPRFRL	-0.011	0.052	-0.003	0.033
MBLACK	-0.164	-0.11	-0.157	-0.106
CSex	-0.099*	-0.065	-0.067	-0.031
MPPVT	0.003	0.0009	0.004*	0.0008
MTRAD	-0.006**	-0.012***	-0.006**	-0.013***
MPLOC	0.005	-0.004	0.004	-0.006*
MBenWk	0.0007	-0.026***	-0.002	-0.028***
CBWtg	-0.043	-0.12**	-0.048	-0.125**
MCstWk	0.003	0.016***	0.005	0.02***
ChiSup	0.014	-0.016	0.022	-0.017
HINC	0.055	0.082*	0.061	0.087**
FINC	0.161***	0.272***	0.158***	0.272***

	Unobserved heterogeneity		No unobserved heterogeneity	
	Price day care centers	Price home care	Price day care centers	Price home care
MPrWork	-0.0003	-0.046	-0.005	-0.077
PrPaidCare	-0.008	-0.083	-0.062	-0.132
MEduc	0.074^{***}	0.102^{***}	0.069^{***}	0.093^{***}
MAge	0.011^{*}	0.006	0.01	0.003
MwHusb	-0.187	0.118	-0.168	0.132
NAdult	-0.021	0.027	-0.0009	0.014
NChild	-0.093^{***}	-0.258^{***}	-0.1^{***}	-0.264^{***}
Infant<6m	-0.298	-0.073	-0.22	-0.153
RATDC	0.05^{***}	0.004	0.057^{***}	0.012
SIZEDC	-0.003	-0.008	-0.003	-0.005
ESIZEDC	0.316	0.795	0.442	0.673
RATFH	-0.152^{*}	-0.055	-0.057	-0.016
SIZEFH	0.175^{**}	0.035	0.056	-0.008
CCDF	0.021^{*}	0.021	0.006	0.027^{*}
NDC1000	-0.006	-0.018	-0.0006	-0.009
Site1	1.475^{***}	0.731^{***}	1.522^{***}	0.837^{***}
Site2	1.104^{**}	1.073^{*}	0.907	0.925
Site3	2.113^{***}	1.275^{***}	2.355^{***}	1.564^{***}
Site4	1.145^{***}	0.433	1.206^{***}	0.784^{**}
Site5	1.458^{***}	1.05^{***}	1.755^{***}	1.421^{***}
Site6	0.35	0.204	0.898^{*}	0.469
Site7	1.112^{***}	1.461^{***}	1.652^{***}	1.624^{***}
Site8	-0.064	-0.051	0.183	0.101
Site9	1.386^{***}	0.933^{***}	1.532^{***}	1.187^{***}
Factor loadings				
t_{0-9m}	-0.21^{**}	-0.079	–	–
t_{10-18}	-0.189^{**}	-0.172^{***}	–	–
t_{19-30}	-0.081	-0.144^{**}	–	–
t_{31-42}	-0.119^{**}	-0.079	–	–
t_{43-57}	-0.115^{***}	-0.102	–	–
St. dev. of the errors				
t_{0-9m}	0.757^{***}	0.92^{***}	0.774^{***}	1.003^{***}
t_{10-18}	0.949^{***}	0.943^{***}	0.941^{***}	0.948^{***}
t_{19-30}	0.813^{***}	0.879^{***}	0.817^{***}	0.887^{***}
t_{31-42}	0.935^{***}	0.92^{***}	0.944^{***}	0.918^{***}
t_{43-57}	0.934^{***}	0.984^{***}	0.935^{***}	0.983^{***}
Observations	1366	1494	1366	1494

$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table D.2: Estimation results for the logarithm of wage equation

	Unobserved heterogeneity	No unobserved heterogeneity
Variables		
Constant	-0.526***	-0.616***
t_{10-18}	-0.075***	-0.08***
t_{19-30}	-0.105***	-0.112***
t_{31-42}	-0.086***	-0.091***
t_{43-57}	-0.162***	-0.172***
MPartTime	0.129***	0.179***
MFullTime	0.305***	0.298***
MPrWork	0.156***	0.111***
MEduc	0.084***	0.088***
MAge	0.069***	0.077***
MAge Squared	-0.0008***	-0.0009***
Site1	0.474***	0.406***
Site2	-0.021	-0.085**
Site3	0.311***	0.25***
Site4	0.179***	0.105**
Site5	0.362***	0.321***
Site6	0.152***	0.068*
Site7	0.317***	0.251***
Site8	0.041	-0.031
Site9	0.147***	0.034
Factor loadings		
t_{0-9m}	0.031*	–
t_{10-18}	0.037**	–
t_{19-30}	0.037**	–
t_{31-42}	0.027*	–
t_{43-57}	0.039**	–
St. dev. of the errors		
t_{0-9m}	0.541***	0.54***
t_{10-18}	0.534***	0.535***
t_{19-30}	0.554***	0.556***
t_{31-42}	0.537***	0.534***
t_{43-57}	0.576***	0.579***
Observations	4026	4026

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

Table D.3: Discrete choice model: Estimation results (with unobserved heterogeneity)

	Work & Paid Day Care Center	Work & Paid Home Care	Work & No Paid Care	No Work & Paid Day Care Center	No Work & Paid Home Care
Variables					
Constant	-1.466	-2.66**	-1.67	0.632	-2.669
t_{10-18}	-1.625	-1.493	-0.585	0.407	-2.102
t_{19-30}	-0.411	-0.4	0.596	-1.169	-0.355
t_{31-42}	-1.741	-1.755	0.879	0.134	-1.002
t_{43-57}	-3.849***	-3.492***	-0.382	-1.449	-2.172
LWage$\times t_{0-9m}$	2.695***	3.262***	0.476	–	–
LWage$\times t_{10-18m}$	2.586***	3.115***	0.637	–	–
LWage$\times t_{19-30m}$	2.443***	3.289***	0.235	–	–
LWage$\times t_{31-42m}$	3.033***	3.831***	0.036	–	–
LWage$\times t_{43-57m}$	3.812***	4.682***	1.118**	–	–
PriceDC$\times t_{0-9m}$	-1.262***	–	–	-0.905***	–
PriceDC$\times t_{10-18m}$	-1.045***	–	–	-1.231***	–
PriceDC$\times t_{19-30m}$	-1.161***	–	–	-0.276	–
PriceDC$\times t_{31-42m}$	-0.92***	–	–	-0.289	–
PriceDC$\times t_{43-57m}$	-0.584**	–	–	0.366	–
PriceHC$\times t_{0-9m}$	–	-0.791***	–	–	0.617*
PriceHC$\times t_{10-18m}$	–	-0.51**	–	–	1.415***
PriceHC$\times t_{19-30m}$	–	-0.984***	–	–	1.053***
PriceHC$\times t_{31-42m}$	–	-0.885***	–	–	1.408***
PriceHC$\times t_{43-57m}$	–	-1.001***	–	–	1.504**
MPRFDC	0.127	-1.192***	-0.262	0.451	-0.789*
MPRFRL	-0.176	-0.281**	-0.078	-0.024	-0.641***
MBLACK	-0.189	-0.348*	0.079	0.13	-0.345
CSex	0.039	0.086	-0.065	0.129	-0.047
MPPVT	-0.003	-0.003	-0.004	-0.005	0.004
MTRAD	-0.014***	-0.005	-0.003	-0.024***	-0.009
MPLOC	-0.001	-0.008	-0.005	-0.004	-0.002
MBenWk	0.074***	0.087***	0.021	-0.009	-0.043
CBWtg	0.228*	0.027	0.13	-0.053	-0.109
MCstWk	-0.066***	-0.067***	-0.043***	-0.045***	-0.028
ChiSup	-0.081	0.115	-0.192	-0.182	-0.292
HINC	0.015	0.027	0.058	0.182	0.445***
FINC	0.082	-0.072	-0.881***	0.53***	0.723***
MPrWork	2.067***	2.306***	2.373***	-0.681***	-0.668***
PrPaidCare	2.113***	2.792***	0.089	1.802***	2.527***
MEduc	-0.084	-0.112*	0.015	0.18***	0.087
MAge	-0.026	-0.058***	-0.015	0.03*	0.011
MwHusb	0.042	-0.034	0.815***	-0.542*	-0.912**
NAdult	-0.173	-0.051	0.145	0.082	-0.053
NChild	-0.347***	-0.225***	0.01	-0.37***	-0.254**
Infant<6m	-2.713***	-2.225***	-1.909***	-0.233	0.691
RATDC	-0.009	-0.099**	0.005	-0.04	-0.099
SIZEDC	-0.007	0.012	-0.003	-0.009	0.034

	Work & Paid Day Care Center	Work & Paid Home Care	Work & No Paid Care	No Work & Paid Day Care Center	No Work & Paid Home Care
ESIZEDC	0.384	-1.147	0.456	1.249	-2.227
RATFH	-0.013	0.024	0.039	0.019	-0.056
SIZEFH	0.016	-0.022	-0.011	-0.06	0.019
CCDF	-0.032	-0.038	-0.014	0.05^{*}	-0.117^{**}
NDC1000	0.018^{***}	0.026^{***}	0.013^{***}	0.007	0.03^{***}
Factor loadings					
t_{0-9m}	0.227	0.064	-0.603^{***}	-0.432	-0.761^{***}
t_{10-18m}	-0.201	-0.242	-0.967^{***}	-0.774^{***}	-0.62^{**}
t_{19-30m}	-0.369^{*}	-0.281	-0.915^{***}	-0.508^{*}	-0.515^{*}
t_{31-42m}	-0.7^{***}	-0.551^{***}	-1.14^{***}	-0.566^{**}	-0.683^{**}
t_{43-57m}	-0.742^{***}	-0.416^{*}	-0.669^{***}	-0.37	-0.919^{*}
Number of total observations = 6188					

Note: The (–) sign reflects the coefficient restrictions on state-specific variables. The base category is No work & No paid care.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table D.4: Childcare choices and unobserved heterogeneity: Statistically significant correlation coefficients

	Within periods ($t = s$)				Across periods($t \neq s$)				
			Max. absolute value				Max. absolute value		
	Number of coefficients	Average value	Value	Period t	Number of coefficients	Average value	Value	Period t	Period s
Work & Paid day care center $\left(\eta_t^{V_1}\right)$									
$corr\left(\eta_t^{V_1}, \eta_s^{w}\right)$	0	–	–	–	2	-0.032	-0.033	t_{31-42m}	t_{10-18m}
$corr\left(\eta_t^{V_1}, \eta_s^{p_d}\right)$	1	0.061	0.061	t_{43-57m}	3	0.107	0.134	t_{43-57m}	t_{0-9m}
$corr\left(\eta_t^{V_1}, \eta_s^{F_d^p}\right)$	3	-0.206	-0.236	t_{31-42m}	12	-0.225	-0.292	t_{43-57m}	t_{0-9m}
$corr\left(\eta_t^{V_1}, \eta_s^{Q_d^p}\right)$	0	–	–	–	0	–	–	–	–
$corr\left(\eta_t^{V_1}, \eta_s^{F_h^f}\right)$	3	0.266	0.328	t_{31-42m}	12	0.261	0.358	t_{43-57m}	t_{19-30m}
$corr\left(\eta_t^{V_1}, \eta_s^{E}\right)$	0	–	–	–	0	–	–	–	–
Work & Paid home care $\left(\eta_t^{V_2}\right)$									
$corr\left(\eta_t^{V_2}, \eta_s^{w}\right)$	0	–	–	–	0	–	–	–	–
$corr\left(\eta_t^{V_2}, \eta_s^{p_h}\right)$	0	–	–	–	2	0.068	0.071	t_{31-42m}	t_{10-18m}
$corr\left(\eta_t^{V_2}, \eta_s^{F_h^p}\right)$	1	-0.249	-0.249	t_{31-42m}	4	-0.229	-0.276	t_{31-42m}	t_{10-18m}
$corr\left(\eta_t^{V_2}, \eta_s^{Q_h^p}\right)$	0	–	–	–	0	–	–	–	–
$corr\left(\eta_t^{V_2}, \eta_s^{F_d^f}\right)$	1	-0.046	-0.046	t_{31-42m}	3	-0.045	-0.049	t_{31-42m}	t_{43-57m}
$corr\left(\eta_t^{V_2}, \eta_s^{F_h^f}\right)$	1	0.270	0.270	t_{31-42m}	4	0.241	0.282	t_{31-42m}	t_{19-30m}
$corr\left(\eta_t^{V_2}, \eta_s^{E}\right)$	0	–	–	–	0	–	–	–	–
Work & No paid care $\left(\eta_t^{V_3}\right)$									

	Within periods ($t = s$)				Across periods($t \neq s$)				
			Max. absolute value				Max. absolute value		
	Number of coefficients	Average value	Value	Period t	Number of coefficients	Average value	Value	Period t	Period s
$corr\left(\eta_t^{V_3}, \eta_s^{w}\right)$	2	-0.040	-0.041	t_{10-18m}	10	-0.038	-0.045	t_{31-42m}	t_{10-18m}
$corr\left(\eta_t^{V_3}, \eta_s^{F_d^f}\right)$	5	-0.059	-0.078	t_{31-42m}	19	-0.059	-0.082	t_{31-42m}	t_{43-57m}
$corr\left(\eta_t^{V_3}, \eta_s^{F_h^f}\right)$	5	0.349	0.455	t_{31-42m}	20	0.341	0.474	t_{31-42m}	t_{19-30m}
$corr\left(\eta_t^{V_3}, \eta_s^{E}\right)$	0	–	–	–	0	–	–	–	–
No work & Paid day care center $\left(\eta_t^{V_4}\right)$									
$corr\left(\eta_t^{V_4}, \eta_s^{p_d}\right)$	0	–	–	–	3	0.084	0.138	t_{10-18m}	t_{0-9m}
$corr\left(\eta_t^{V_4}, \eta_s^{F_d^p}\right)$	3	-0.230	-0.282	t_{10-18m}	12	-0.226	-0.301	t_{10-18m}	t_{0-9m}
$corr\left(\eta_t^{V_4}, \eta_s^{Q_d^p}\right)$	0	–	–	–	0	–	–	–	–
$corr\left(\eta_t^{V_4}, \eta_s^{F_h^f}\right)$	3	0.292	0.338	t_{10-18m}	12	0.263	0.369	t_{10-18m}	t_{19-30m}
$corr\left(\eta_t^{V_4}, \eta_s^{E}\right)$	0	–	–	–	0	–	–	–	–
No work & Paid home care $\left(\eta_t^{V_5}\right)$									
$corr\left(\eta_t^{V_5}, \eta_s^{p_h}\right)$	2	0.081	0.083	t_{0-9m}	4	0.082	0.091	t_{0-9m}	t_{10-18m}
$corr\left(\eta_t^{V_5}, \eta_s^{F_h^p}\right)$	5	-0.273	-0.304	t_{10-18m}	19	-0.289	-0.407	t_{43-57m}	t_{10-18m}
$corr\left(\eta_t^{V_5}, \eta_s^{Q_h^p}\right)$	0	–	–	–	0	–	–	–	–
$corr\left(\eta_t^{V_5}, \eta_s^{F_d^f}\right)$	3	-0.046	-0.055	t_{31-42m}	11	-0.056	-0.066	t_{43-57m}	t_{10-18m}
$corr\left(\eta_t^{V_5}, \eta_s^{F_h^f}\right)$	5	0.293	0.322	t_{31-42m}	20	0.298	0.416	t_{43-57m}	t_{19-30m}
$corr\left(\eta_t^{V_5}, \eta_s^{E}\right)$	0	–	–	–	0	–	–	–	–

	Within periods ($t = s$)				Across periods($t \neq s$)				
			Max. absolute value				Max. absolute value		
	Number of coefficients	Average value	Value	Period t	Number of coefficients	Average value	Value	Period t	Period s
Hours of paid day care center $\left(\eta_t^{F_d^p}\right)$									
$corr\left(\eta_t^{F_d^p}, \eta_s^w\right)$	3	0.035	0.038	t_{19-30m}	12	0.036	0.040	t_{0-9m}	t_{10-18m}
$corr\left(\eta_t^{F_d^p}, \eta_s^{p_d}\right)$	4	-0.095	-0.156	t_{0-9m}	16	-0.093	-0.151	t_{19-30m}	t_{0-9m}
$corr\left(\eta_t^{F_d^p}, \eta_s^{Q_d^p}\right)$	0	–	–	–	0	–	–	–	–
$corr\left(\eta_t^{F_d^p}, \eta_s^{F_h^f}\right)$	5	-0.331	-0.404	t_{19-30m}	20	-0.330	-0.417	t_{0-9m}	t_{19-30m}
$corr\left(\eta_t^{F_d^p}, \eta_s^E\right)$	0	–	–	–	0	–	–	–	–
Hours of paid home care $\left(\eta_t^{F_h^p}\right)$									
$corr\left(\eta_t^{F_h^p}, \eta_s^w\right)$	3	0.040	0.048	t_{10-18m}	12	0.040	0.047	t_{10-18m}	t_{19-30m}
$corr\left(\eta_t^{F_h^p}, \eta_s^{p_h}\right)$	3	-0.108	-0.125	t_{10-18m}	12	-0.097	-0.121	t_{19-30m}	t_{10-18m}
$corr\left(\eta_t^{F_h^p}, \eta_s^{Q_h^p}\right)$	0	–	–	–	0	–	–	–	–
$corr\left(\eta_t^{F_h^p}, \eta_s^{F_d^f}\right)$	5	0.062	0.079	t_{10-18m}	20	0.062	0.086	t_{10-18m}	t_{43-57m}
$corr\left(\eta_t^{F_h^p}, \eta_s^{F_h^f}\right)$	5	-0.376	-0.481	t_{19-30m}	20	-0.369	-0.499	t_{10-18m}	t_{19-30m}
$corr\left(\eta_t^{F_h^p}, \eta_s^E\right)$	0	–	–	–	0	–	–	–	–
Hours of free home care $\left(\eta_t^{F_h^f}\right)$									
$corr\left(\eta_t^{F_h^f}, \eta_s^w\right)$	3	-0.043	-0.048	t_{19-30m}	12	-0.042	-0.049	t_{19-30m}	t_{10-18m}
$corr\left(\eta_t^{F_h^f}, \eta_s^{p_d}\right)$	4	0.106	0.143	t_{0-9m}	16	0.113	0.191	t_{19-30m}	t_{0-9m}

	Within periods ($t = s$)				Across periods($t \neq s$)				
			Max. absolute value				Max. absolute value		
	Number of coefficients	Average value	Value	Period t	Number of coefficients	Average value	Value	Period t	Period s
$corr\left(\eta_t^{F_h^f}, \eta_s^{p_h}\right)$	3	0.107	0.117	t_{10-18m}	12	0.105	0.128	t_{19-30m}	t_{10-18m}
$corr\left(\eta_t^{F_h^f}, \eta_s^{F_d^f}\right)$	5	-0.067	-0.080	t_{31-42m}	20	-0.066	-0.088	t_{19-30m}	t_{43-57m}
$corr\left(\eta_t^{F_h^f}, \eta_s^{E}\right)$	0	–	–	–	0	–	–	–	–

Note: Summary statistics included only for coefficients significant at 5%.
The maximum number of statistically significant coefficients is 5 for correlations within periods and 20 for correlations across periods.

Table D.5: Discrete choice model: Time and price effects with unobserved heterogeneity

	Work & Paid Day Care Center	Work & Paid Home Care	Work & No Paid Care	No Work & Paid Day Care Center	No Work & Paid Home Care	No Work & No Paid Care
t_{10-18}	0.047	0.062	0.004	-0.005	-0.002	-0.107^{***}
t_{19-30}	0.125^{***}	0.016	-0.024	0.011^{*}	0.0004	-0.128^{***}
t_{31-42}	0.297^{***}	-0.048	-0.133^{***}	0.044^{***}	-0.005	-0.155^{***}
t_{43-57}	0.439^{***}	-0.195^{***}	-0.144^{***}	0.083^{***}	-0.009^{**}	-0.175^{***}
LWage$\times t_{0-9m}$	0.157^{*}	0.551^{***}	-0.309^{***}	-0.026^{***}	-0.027^{***}	-0.346^{***}
LWage$\times t_{10-18m}$	0.118	0.46^{***}	-0.344^{***}	-0.021^{***}	-0.027^{***}	-0.185^{***}
LWage$\times t_{19-30m}$	0.126	0.486^{***}	-0.389^{***}	-0.053^{***}	-0.03^{***}	-0.14^{***}
LWage$\times t_{31-42m}$	0.192^{*}	0.383^{***}	-0.284^{***}	-0.153^{***}	-0.026^{***}	-0.112^{***}
LWage$\times t_{43-57m}$	0.365^{***}	0.249^{***}	-0.207^{***}	-0.314^{***}	-0.019^{**}	-0.074^{***}
PriceDC$\times t_{0-9m}$	-0.172^{***}	0.081^{***}	0.054^{***}	-0.01^{*}	0.003^{***}	0.044^{***}
PriceDC$\times t_{10-18m}$	-0.172^{***}	0.1^{***}	0.058^{***}	-0.01^{***}	0.003^{***}	0.021^{***}
PriceDC$\times t_{19-30m}$	-0.237^{***}	0.131^{***}	0.075^{***}	0.002	0.005^{***}	0.024^{***}
PriceDC$\times t_{31-42m}$	-0.221^{***}	0.14^{***}	0.049^{***}	0.009	0.004^{***}	0.019^{***}
PriceDC$\times t_{43-57m}$	-0.161^{***}	0.054^{*}	0.031^{*}	0.067^{*}	0.002	0.007^{*}
PriceHC$\times t_{0-9m}$	0.046^{***}	-0.187^{***}	0.068^{***}	0.004^{***}	0.014^{**}	0.055^{***}
PriceHC$\times t_{10-18m}$	0.042^{**}	-0.133^{***}	0.049^{**}	0.002^{*}	0.022^{***}	0.018^{**}
PriceHC$\times t_{19-30m}$	0.104^{***}	-0.238^{***}	0.078^{***}	0.009^{***}	0.021^{***}	0.025^{***}
PriceHC$\times t_{31-42m}$	0.123^{***}	-0.196^{***}	0.029^{***}	0.016^{***}	0.017^{***}	0.011^{***}
PriceHC$\times t_{43-57m}$	0.097^{***}	-0.142^{***}	0.016^{***}	0.016^{***}	0.01	0.004^{**}

Note: The marginal effects are estimated at the means of the observable characteristics and the unobservable factor.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table D.6: Discrete choice model: Marginal effects for demographics and policy variables

	Unobserved heterogeneity			No unobserved heterogeneity		
	Work	Paid Day Care Center	Paid Home Care	Work	Paid Day Care Center	Paid Home Care
Age 0 to 9 months						
MPRFDC	-0.094**	0.116***	-0.223***	-0.106***	0.105***	-0.203***
MPRFRL	-0.026	-5×10^{-4}	-0.051***	-0.034**	-0.003	-0.062***
MBLACK	-0.028	-0.005	-0.076**	-0.032	-0.006	-0.092***
CSex	0.004	0.004	0.022	0.004	0.004	0.015
MPPVT	-5×10^{-4}	-6×10^{-5}	-1×10^{-4}	-3×10^{-4}	3×10^{-5}	-1×10^{-4}
MTRAD	-7×10^{-4}	-0.002***	2×10^{-4}	-5×10^{-4}	-0.002***	2×10^{-4}
MPLOC	-9×10^{-4}	5×10^{-4}	-0.001	-0.001	6×10^{-4}	-7×10^{-4}
MBenWk	0.012***	0.003*	0.013***	0.014***	0.003*	0.013***
CBWtg	0.02	0.023**	-0.021	0.025	0.017*	-0.019
MCstWk	-0.01***	-0.003**	-0.007***	-0.011***	-0.003**	-0.008***
ChiSup	0.002	-0.012	0.048	0.008	-0.012	0.045
HINC	-0.001	-0.001	0.003	-0.002	0.002	0.009
FINC	-0.066***	0.059***	0.063***	-0.08***	0.056***	0.094***
MPrWork	0.516***	0.03	0.188***	0.578***	0.024	0.195***
PrPaidCare	0.169***	1×10^{-3}	0.382***	0.167***	-1×10^{-3}	0.434***
MEduc	-0.015*	-0.003	-0.022**	-0.009	-0.005	-0.008
MAge	-0.007***	0.001	-0.01***	-0.006**	-6×10^{-6}	-0.007*
MwHusb	0.061**	-0.032	-0.091***	0.058**	-0.028	-0.109***
NAdult	-0.003	-0.025*	-0.015	3×10^{-4}	-0.022*	-0.026
NChild	-0.024***	-0.037***	-0.03***	-0.024***	-0.031***	-0.033***
Infant<6m	-0.398***	-0.143***	-0.149**	-0.379***	-0.115***	-0.135*
RATDC	-0.007	0.005	-0.023***	-0.004	0.006*	-0.02***
SIZEDC	3×10^{-4}	-0.002	0.004	0.002	-0.002	0.005
ESIZEDC	-0.039	0.125	-0.333	-0.196	0.095	-0.376*
RATFH	0.004	-0.005	0.002	0.002	-0.004	-0.001
SIZEFH	-0.001	0.003	-0.004	-7×10^{-4}	0.002	-0.001
CCDF	-0.004	-3×10^{-4}	-0.007	-0.005	-6×10^{-4}	-0.009**
NDC1000	0.003***	2×10^{-4}	0.004***	0.003***	1×10^{-4}	0.004***
Age 10 to 18 months						
MPRFDC	-0.054**	0.159***	-0.245***	-0.055**	0.153***	-0.212***
MPRFRL	-0.012	0.004	-0.047***	-0.015	4×10^{-4}	-0.055***
MBLACK	-0.016	-0.003	-0.077**	-0.017	-0.005	-0.092***
CSex	0.003	0.003	0.023	0.002	0.004	0.014
MPPVT	-3×10^{-4}	1×10^{-5}	-6×10^{-5}	-2×10^{-4}	8×10^{-5}	-1×10^{-4}
MTRAD	-3×10^{-4}	-0.002***	6×10^{-4}	-2×10^{-4}	-0.002***	6×10^{-4}
MPLOC	-5×10^{-4}	7×10^{-4}	-0.001	-6×10^{-4}	1×10^{-3}	-5×10^{-4}
MBenWk	0.007***	0.003	0.011***	0.008***	0.003	0.011***
CBWtg	0.012	0.028**	-0.029*	0.015*	0.022*	-0.028*
MCstWk	-0.005***	-0.003*	-0.005***	-0.006***	-0.002*	-0.006***
ChiSup	0.004	-0.015	0.055*	0.006	-0.016	0.051*

	Unobserved heterogeneity			No unobserved heterogeneity		
	Work	Paid Day Care Center	Paid Home Care	Work	Paid Day Care Center	Paid Home Care
HINC	-0.004	-0.003	0.001	-0.004	0.001	0.007
FINC	-0.04***	0.071***	0.074***	-0.049***	0.077***	0.107***
MPrWork	0.366***	0.004	0.124***	0.425***	-0.004	0.121***
PrPaidCare	0.131***	0.075***	0.428***	0.104***	0.096***	0.477***
MEduc	-0.01**	-0.003	-0.021**	-0.007	-0.008	-0.006
MAge	-0.004***	0.002	-0.01***	-0.004***	3×10^{-4}	-0.006*
MwHusb	0.038**	-0.036	-0.105***	0.039**	-0.037	-0.121***
NAdult	-0.003	-0.031*	-0.012	-0.001	-0.031**	-0.026
NChild	-0.013**	-0.039***	-0.023**	-0.012**	-0.037***	-0.025**
Infant<6m	-0.235***	-0.136***	-0.064	-0.224***	-0.124**	-0.054
RATDC	-0.003	0.008	-0.024***	-0.002	0.009**	-0.022***
SIZEDC	3×10^{-5}	-0.002	0.004	9×10^{-4}	-0.002	0.005
ESIZEDC	-0.018	0.153	-0.347	-0.114	0.138	-0.352*
RATFH	0.002	-0.006	0.002	0.001	-0.006	-8×10^{-4}
SIZEFH	-6×10^{-4}	0.005	-0.005	-1×10^{-4}	0.004	-0.002
CCDF	-0.002	-2×10^{-4}	-0.006	-0.002	-7×10^{-4}	-0.008**
NDC1000	0.002***	-2×10^{-4}	0.003***	0.002***	-2×10^{-4}	0.003***
Age 19 to 30 months						
MPRFDC	-0.051**	0.193***	-0.237***	-0.049**	0.191***	-0.206***
MPRFRL	-0.01	0.007	-0.043***	-0.013	0.003	-0.049***
MBLACK	-0.018	1×10^{-4}	-0.069**	-0.018	-0.004	-0.081***
CSex	9×10^{-4}	0.004	0.019	-4×10^{-4}	0.006	0.011
MPPVT	-2×10^{-4}	3×10^{-6}	-2×10^{-5}	-2×10^{-4}	9×10^{-5}	-9×10^{-5}
MTRAD	-3×10^{-5}	-0.002***	1×10^{-3}	8×10^{-5}	-0.002***	0.001
MPLOC	-4×10^{-4}	9×10^{-4}	-0.001	-4×10^{-4}	0.001	-6×10^{-4}
MBenWk	0.007***	0.003	0.009***	0.008***	0.003	0.009***
CBWtg	0.014	0.032**	-0.031*	0.016*	0.026*	-0.029**
MCstWk	-0.005***	-0.003	-0.004**	-0.005***	-0.002	-0.005***
ChiSup	0.006	-0.02	0.053*	0.007	-0.021	0.049*
HINC	-0.007	-0.003	0.002	-0.007	0.002	0.006
FINC	-0.044***	0.092***	0.051**	-0.051***	0.105***	0.079***
MPrWork	0.398***	-0.041	0.113***	0.449***	-0.056*	0.11***
PrPaidCare	0.108***	0.107***	0.37***	0.08***	0.142***	0.405***
MEduc	-0.012***	-0.001	-0.019*	-0.01**	-0.008	-0.005
MAge	-0.004***	0.003	-0.009***	-0.004***	1×10^{-3}	-0.006*
MwHusb	0.044***	-0.05*	-0.085***	0.045***	-0.053*	-0.1***
NAdult	-0.005	-0.037*	-0.006	-0.004	-0.039**	-0.017
NChild	-0.008	-0.048***	-0.011	-0.008	-0.048***	-0.013
Infant<6m	-0.231***	-0.146**	-0.027	-0.218***	-0.137**	-0.02
RATDC	-0.002	0.01	-0.023***	-3×10^{-4}	0.012**	-0.021***
SIZEDC	-1×10^{-5}	-0.003	0.004	8×10^{-4}	-0.003	0.005
ESIZEDC	-0.031	0.198	-0.338	-0.121	0.197	-0.337*
RATFH	0.002	-0.007	0.003	6×10^{-4}	-0.007	2×10^{-4}
SIZEFH	5×10^{-4}	0.005	-0.005	0.001	0.004	-0.002
CCDF	-0.003	6×10^{-4}	-0.005	-0.003	-1×10^{-4}	-0.008**

	Unobserved heterogeneity			No unobserved heterogeneity		
	Work	Paid Day Care Center	Paid Home Care	Work	Paid Day Care Center	Paid Home Care
NDC1000	0.001^{***}	-4×10^{-4}	0.003^{***}	0.001^{***}	-4×10^{-4}	0.003^{***}
Age 31 to 42 months						
MPRFDC	-0.054^{**}	0.217^{***}	-0.219^{***}	-0.05^{**}	0.216^{***}	-0.2^{***}
MPRFRL	-0.013	0.014	-0.034^{**}	-0.015	0.011	-0.038^{***}
MBLACK	-0.027	0.014	-0.053^{*}	-0.026	0.012	-0.063^{**}
CSex	-0.002	0.002	0.012	-0.004	0.006	0.006
MPPVT	-7×10^{-5}	-1×10^{-5}	-2×10^{-5}	-5×10^{-5}	1×10^{-4}	-1×10^{-4}
MTRAD	4×10^{-4}	-0.003^{***}	0.002^{**}	5×10^{-4}	-0.003^{***}	0.002^{**}
MPLOC	-2×10^{-4}	0.001	-0.001	-2×10^{-4}	0.001	-9×10^{-4}
MBenWk	0.008^{***}	9×10^{-4}	0.006^{**}	0.008^{***}	8×10^{-4}	0.007^{**}
CBWtg	0.018^{*}	0.038^{**}	-0.033^{**}	0.019^{*}	0.032^{*}	-0.03^{**}
MCstWk	-0.004^{***}	-0.002	-0.002	-0.004^{***}	-0.002	-0.003^{*}
ChiSup	0.009	-0.031	0.046	0.009	-0.033	0.046^{*}
HINC	-0.011	-0.002	9×10^{-4}	-0.01	0.003	0.002
FINC	-0.043^{***}	0.092^{***}	-0.001	-0.048^{***}	0.104^{***}	0.019
MPrWork	0.437^{***}	-0.092^{***}	0.132^{***}	0.483^{***}	-0.11^{***}	0.139^{***}
PrPaidCare	0.1^{***}	0.093^{***}	0.252^{***}	0.081^{***}	0.144^{***}	0.283^{***}
MEduc	-0.018^{***}	0.004	-0.015	-0.016^{***}	-0.006	-0.002
MAge	-0.005^{***}	0.006^{*}	-0.008^{***}	-0.005^{***}	0.002	-0.005^{*}
MwHusb	0.047^{**}	-0.042	-0.039	0.047^{**}	-0.046	-0.052^{*}
NAdult	-0.013	-0.036	0.008	-0.013	-0.037^{*}	-8×10^{-4}
NChild	-0.004	-0.049^{***}	0.009	-0.004	-0.051^{***}	0.006
Infant<6m	-0.235^{***}	-0.135^{*}	0.013	-0.227^{***}	-0.132^{*}	0.012
RATDC	-9×10^{-4}	0.014^{*}	-0.02^{***}	1×10^{-3}	0.016^{**}	-0.02^{***}
SIZEDC	2×10^{-4}	-0.004	0.004	1×10^{-3}	-0.004	0.005
ESIZEDC	-0.073	0.262	-0.311	-0.159	0.268	-0.319^{*}
RATFH	2×10^{-4}	-0.008	0.005	-0.001	-0.008	0.003
SIZEFH	0.003	0.006	-0.005	0.004	0.005	-0.003
CCDF	-0.005^{**}	0.002	-0.004	-0.005^{**}	0.002	-0.006^{*}
NDC1000	0.001^{***}	-1×10^{-3}	0.002^{***}	0.001^{***}	-1×10^{-3}	0.002^{***}
Age 43 to 57 months						
MPRFDC	-0.054	0.151^{***}	-0.13^{***}	-0.046	0.159^{***}	-0.134^{***}
MPRFRL	-0.015	0.009	-0.022^{**}	-0.016	0.011	-0.025^{**}
MBLACK	-0.033	0.005	-0.033^{*}	-0.031	0.012	-0.04^{**}
CSex	-0.007	0.005	0.007	-0.008	0.005	0.003
MPPVT	7×10^{-5}	-1×10^{-6}	4×10^{-6}	5×10^{-5}	1×10^{-4}	-9×10^{-5}
MTRAD	9×10^{-4}	-0.002^{***}	0.001^{**}	9×10^{-4}	-0.002^{***}	0.001^{***}
MPLOC	2×10^{-5}	9×10^{-4}	-7×10^{-4}	2×10^{-5}	0.001	-8×10^{-4}
MBenWk	0.009^{***}	0.001	0.004^{*}	0.009^{***}	5×10^{-5}	0.004^{*}
CBWtg	0.025^{*}	0.028^{*}	-0.022^{**}	0.023^{*}	0.026^{*}	-0.022^{**}
MCstWk	-0.003^{**}	-0.002	-1×10^{-3}	-0.004^{**}	-0.001	-0.002
ChiSup	0.011	-0.021	0.031	0.01	-0.028	0.033
HINC	-0.015	-0.001	1×10^{-4}	-0.013	0.003	3×10^{-4}
FINC	-0.055^{***}	0.097^{***}	-0.009	-0.051^{***}	0.086^{***}	-0.006

	Unobserved heterogeneity			No unobserved heterogeneity		
	Work	Paid Day Care Center	Paid Home Care	Work	Paid Day Care Center	Paid Home Care
MPrWork	0.482^{***}	-0.106^{***}	0.086^{***}	0.501^{***}	-0.109^{***}	0.102^{***}
PrPaidCare	0.058^{***}	0.183^{***}	0.137^{***}	0.056^{***}	0.177^{***}	0.153^{***}
MEduc	-0.025^{***}	0.002	-0.01^{*}	-0.022^{***}	-0.004	-9×10^{-4}
MAge	-0.006^{***}	0.004^{*}	-0.006^{***}	-0.005^{***}	0.002	-0.004
MwHusb	0.064^{**}	-0.057^{**}	-0.018	0.056^{**}	-0.038	-0.023
NAdult	-0.019	-0.033^{*}	0.007	-0.019	-0.03	0.005
NChild	0.002	-0.046^{***}	0.01	2×10^{-4}	-0.041^{***}	0.012^{*}
Infant<6m	-0.263^{***}	-0.1^{*}	0.017	-0.24^{***}	-0.094^{*}	0.023
RATDC	0.001	0.009	-0.013^{***}	0.003	0.014^{**}	-0.014^{***}
SIZEDC	3×10^{-4}	-0.003	0.003	1×10^{-3}	-0.004	0.003
ESIZEDC	-0.1	0.185	-0.198	-0.182	0.218	-0.221^{*}
RATFH	-0.001	-0.007	0.003	-0.003	-0.006	0.003
SIZEFH	0.006	0.004	-0.003	0.007	0.004	-0.002
CCDF	-0.007^{***}	0.002	-0.003	-0.007^{***}	0.002	-0.004
NDC1000	0.001^{**}	-7×10^{-4}	0.001^{***}	0.001^{**}	-9×10^{-4}	0.002^{**}

Note: The marginal effects are estimated at the means of the observable characteristics and the unobservable factor.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table D.7: Characteristics of care: Coefficients for demographic and policy variables in equations with time-varying price effects

	Unobserved heterogeneity				No unobserved heterogeneity			
	Hours paid day care center	Hours paid home care	Hours free home care	Home goods	Hours paid day care center	Hours paid home care	Hours free home care	Home goods
Variables								
MPRFDC	2.61***	0.672	0.181	0.016	4.42***	2.71*	-1.326**	0.011
MPRFRL	0.57	-0.593	0.86***	-0.054**	0.502	-0.238	0.884***	-0.053**
MBLACK	0.002	-3.687***	1.94***	-0.494***	0.307	-4.516***	2.409***	-0.491***
CSex	1.105**	1.303**	-1.179***	-0.039*	-0.012	-0.128	-0.17	-0.036*
MPPVT	0.027	0.008	-0.045***	0.002**	-0.001	0.003	-0.026**	0.002**
MTRAD	0.014	0.03	0.023*	-0.004***	-0.006	0.08***	0.013	-0.004***
MPLOC	-0.104***	-0.053	0.024	-0.008***	-0.057	0.002	-0.034*	-0.008***
MBenWk	0.484***	0.704***	0.064	-0.012***	0.56***	0.685***	0.133**	-0.012***
CBWtg	0.186	-0.029	-0.462	0.04*	0.484	0.541	-0.405	0.041*
MCstWk	-0.368***	-0.395***	-0.134***	0.003	-0.428***	-0.616***	-0.115***	0.003
ChiSup	1.086	0.326	0.828*	-0.004	0.675	0.868	1.205**	-0.004
HINC	0.503	-0.967**	-0.656***	0.037*	0.374	-1.162**	-0.708***	0.038**
FINC	-0.537*	-0.541	-1.178***	0.065***	-0.278	-0.199	-1.291***	0.064***
MPrWork	4.452***	1.488	2.592***	0.101***	3.856***	2.507*	4.934***	0.105***
PrPaidCare	10.127***	7.971***	-2.596***	-0.024	13.216***	12.463***	-6.661***	-0.035
MEduc	-0.458**	-0.928***	0.0007	0.08***	-0.188	-0.18	0.06	0.083***
MAge	-0.064	-0.165**	0.027	0.024***	0.027	0.083	0.023	0.025***
MwHusb	-4.204***	-6.676***	1.969***	0.366***	-5.193***	-7.04***	2.104***	0.367***
NAdult	-0.318	-1.749***	1.313***	0.014	-1.706**	-0.927	1.922***	0.015
NChild	-1.702***	-0.584*	0.293*	-0.144***	-2.146***	-0.462	-0.053	-0.145***
Infant<6m	-5.158***	-6.317***	-5.754***	0.043	-8.006***	-5.079**	-4.198***	0.05
RATDC	-0.019	0.068	0.015	0.006	0.224	0.442**	-0.066	0.007

	Unobserved heterogeneity				No unobserved heterogeneity			
	Hours paid day care center	Hours paid home care	Hours free home care	Home goods	Hours paid day care center	Hours paid home care	Hours free home care	Home goods
SIZEDC	-0.002	0.073	0.056	-0.007*	-0.13	0.056	0.11**	-0.007*
ESIZEDC	0.791	-7.458	-4.687	0.412	11.322	-4.626	-9.725**	0.411
RATFH	0.435	0.05	-0.057	-0.042***	0.779*	0.07	-0.108	-0.042***
SIZEFH	-0.611**	0.044	0.189**	0.034***	-0.711**	0.248	0.106	0.034***
CCDF	-0.059	-0.023	-0.019	0.003	-0.123	-0.141	0.09	0.003
NDC1000	0.073***	-0.015	0.011	-0.001	0.06***	0.005	0.003	-0.001
Constant	24.78***	40.871***	6.977*	-1.34***	26.44***	9.54	3.656	-1.407***
Factor loadings								
t_{0-9m}	6.506***	6.397***	-5.388***	0.008	–	–	–	–
t_{10-18}	6.657***	8.848***	-8.533***	0.004	–	–	–	–
t_{19-30}	6.718***	8.832***	-8.8***	-0.016	–	–	–	–
t_{31-42}	5.86***	8.024***	-8.116***	-0.014	–	–	–	–
t_{43-57}	5.161***	4.98***	-6.625***	-0.05*	–	–	–	–
St. dev. of the errors								
t_{0-9m}	9.059***	9.542***	8.559***	0.842***	11.8***	11.549***	10.232***	0.843***
t_{10-18}	10.198***	9.053***	9.879***	0.851***	12.054***	12.372***	13.137***	0.851***
t_{19-30}	9.802***	9.696***	8.628***	0.788***	11.98***	12.89***	12.331***	0.789***
t_{31-42}	10.379***	9.845***	8.636***	0.843***	11.8***	12.679***	11.849***	0.843***
t_{43-57}	10.213***	11.633***	10.142***	0.823***	11.545***	13.089***	12.077***	0.825***
Observations	1780	2003	6188	5957	1780	2003	6188	5957

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

Table D.8: Estimation results quality of free day care centers

	Unobserved heterogeneity	No unobserved heterogeneity
Constant	2.6064^{***}	2.6316^{***}
t_{19-30}, t_{31-42}	0.023481	-0.00555
t_{43-57}	0.33347^{**}	0.33436^{**}
Site1	0.58968^{***}	0.64121^{***}
Site2	0.1124	0.02808
Site3	0.15343	0.1028
Site4	-0.04543	-0.0869
Site5	0.025862	0.05794
Site6	0.28416^{*}	0.2831^{*}
Site7	0.14962	0.15447
Site8	0.067358	-0.01816
Site9	-0.1351	-0.08598
Factor loading	0.015067	–
St. dev of the errors		
t_{0-9m}	0.548^{***}	0.55587^{***}
t_{10-18}	0.52935^{***}	0.55883^{***}
t_{19-30}	0.43219^{***}	0.43312^{***}
t_{31-42}	0.015067	0.39208^{***}
t_{43-57}	0.53138^{***}	0.52898^{***}
Observations	150	150

Note: The intercept for age groups 19 to 30 months and 31 to 42 months are set to be equal to each other.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table D.9: Estimation results for quality of parenting

	Unobserved heterogeneity	No unobserved heterogeneity
Variables		
MPRFDC	-0.043	-0.072
MPRFRL	0.22^{**}	0.166^{*}
MBLACK	-1.102^{***}	-1.113^{***}
MPPVT	0.007^{**}	0.007^{**}
MTRAD	-0.023^{***}	-0.022^{***}
MPLOC	-0.022^{***}	-0.025^{***}
MBenWk	-0.003	0.003
MCstWk	0.005	0.008
MEduc	0.229^{***}	0.223^{***}
MAge	0.081^{***}	0.08^{***}
MwHusb	1.619^{***}	1.608^{***}
NAdult	0.075	0.077
NChild	-0.363^{***}	-0.375^{***}
Factor loading	-0.154^{***}	–
Observations	1313	1313

$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table D.10: Estimation results for the measures of parenting quality

	t_{0-9m}	t_{10-18m}	t_{31-42m}	t_{43-57m}
Unobserved heterogeneity				
Constant	17.341^{***}	16.434^{***}	17.072^{***}	19.032^{***}
Q_m	1	1.12^{***}	1.388^{***}	1.325^{***}
St. dev. of the error	2.9^{***}	3.198^{***}	5.889^{***}	3.251^{***}
No unobserved heterogeneity				
Constant	17.455^{***}	16.615^{***}	17.215^{***}	19.188^{***}
Q_m	1	1.11^{***}	1.391^{***}	1.325^{***}
St. dev. of the error	2.901^{***}	3.211^{***}	5.889^{***}	3.256^{***}
Observations	1313	1280	1233	1111

Note: The coefficient in front of Q_m is normalized to 1 for the age group 0 to 9 months.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table D.11: Chararacteristics of care: Coefficients for demographic and policy variables in equations with constant price effects

	Unobserved heterogeneity			No unobserved heterogeneity		
	Quality paid day care center	Quality paid home care	Hours free day care center	Quality paid day care center	Quality paid home care	Hours free day care center
Variables						
MPRFDC	-0.0007	0.06	1.208***	0.016	0.104	1.255***
MPRFRL	-0.01	0.099***	0.074	-0.014	0.083**	0.079
MBLACK	-0.109	-0.055	-0.095	-0.111	-0.031	-0.101
CSex	-0.001	-0.065**	-0.113	-0.021	-0.086***	-0.137
MPPVT	0.0008	0.0001	-0.006	0.0004	-0.0002	-0.007*
MTRAD	0.001	-0.003**	-0.005	0.002	-0.004***	-0.005
MPLOC	0.002	0.0008	0.008	0.002	-0.0009	0.01
MBenWk	-0.011*	-0.014**	0.032*	-0.011*	-0.017***	0.027
CBWtg	-0.043	0.01	0.08	-0.042	0.011	0.075
MCstWk	-0.002	0.008**	-0.016	-0.002	0.005	-0.015
ChiSup	0.046	-0.031	-0.185	0.019	-0.037	-0.202
HINC	-0.002	0.077***	-0.073	-0.002	0.054**	-0.063
FINC	0.022	0.082***	-0.283	0.022	0.085***	-0.254
MPrWork	0.051	0.309***	0.178	-0.024	0.181*	0.077
PrPaidCare	-0.057	-0.18**	1.749***	-0.025	-0.09	1.92***
MEduc	0.028**	0.047***	0.084***	0.019	0.043**	0.077**
MAge	0.0008	0.011**	-0.022*	-0.0005	0.01*	-0.024*
MwHusb	0.077	0.078	-0.757***	0.031	0.089	-0.742***
NAdult	-0.005	0.064	-0.24***	-0.049	0.079*	-0.252***
NChild	-0.02	-0.098***	0.151***	-0.017	-0.104***	0.167***
Infant<6m	0.045	0.261**	0.175	0.028	0.27**	0.148
RATDC	0.011	-0.008	0.15***	0.009	-0.003	0.162***
SIZEDC	-0.022***	-0.014***	-0.025	-0.022***	-0.014**	-0.034
ESIZEDC	1.792***	1.195**	2.229	1.798***	1.16**	3.083
RATFH	-0.014	-0.025	0.106**	-0.016	-0.025	0.103**
SIZEFH	0.025	0.008	-0.034	0.029*	0.01	-0.033
CCDF	-0.002	0.017**	0.01	-0.002	0.013*	0.005
NDC1000	-0.002	-0.001	0.002	-0.0009	-0.0008	0.003
Constant	2.577***	1.841***	-0.779	3.058***	2.329***	-0.559
Factor loadings						
t_{0-9m}	0.089	-0.03	0.142**	–	–	–
t_{10-18}	0.071	0.058	0.405***	–	–	–
t_{19-30}	0.071	0.033	0.449***	–	–	–
t_{31-42}	0.011	-0.0007	0.63***	–	–	–
t_{43-57}	0.022	0.045	1.152***	–	–	–
St. dev. of the errors						
t_{0-9m}	0.519***	0.564***	2.111***	0.518***	0.558***	2.113***
t_{10-18}	0.522***	0.502***	3.547***	0.518***	0.504***	3.576***
t_{19-30}	0.479***	0.521***	4.153***	0.473***	0.502***	4.176***

	Unobserved heterogeneity			No unobserved heterogeneity		
	Quality paid day care center	Quality paid home care	Hours free day care center	Quality paid day care center	Quality paid home care	Hours free day care center
t_{31-42}	0.425^{***}	0.436^{***}	5.347^{***}	0.42^{***}	0.423^{***}	5.386^{***}
t_{43-57}	0.552^{***}	0.558^{***}	9.284^{***}	0.548^{***}	0.555^{***}	9.345^{***}
Observations	1019	1053	4408	1019	1053	4408

$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Appendix E

Goodness-of-fit and Model Specification Tests

Table E.1: Tests of alternative specifications

	Log likelihood	Number of parameters	Chi-square test statistic	p-value
Original model	-106320	881		
Model without interactions	-106361.8	863	83.6	0.000
Model without any geographical variables	-107020.9	747	1401.8	0.000
Model without policy variables	-106473.8	783	307.6	0.000
Model without unobserved heterogeneity	-107245.6	803	1851.2	0.000

Note: The likelihood ratio test is used for all alternative specifications.

Table E.2: Goodness-of-fit tests for the discrete choice equation

Age group	Chi-square test statistic	p-value
t_{0-9m}	4.3392	0.502
t_{10-18m}	6.1109	0.306
t_{19-30m}	3.8417	0.573
t_{31-42m}	1.3276	0.931
t_{43-57m}	0.859	0.973

Note: Predicted simulated probabilities were compared with the actual shares of different states for the sample of mothers who are present in the sample until the last age group.

Table E.3: Goodness-of-fit for decision variables and cognitive outcomes

Variable	Actual mean	Predicted mean	Abs. diff (in SD)
Age 0 to 9 months			
Choice 1	0.095	0.102	0.022
Choice 2	0.336	0.345	0.019
Choice 3	0.280	0.257	0.052
Choice 4	0.016	0.018	0.011
Choice 5	0.029	0.035	0.035
Choice 6	0.244	0.245	0.002
$F^p_{0-9m,d}$	2.230	2.344	0.015
$F^p_{0-9m,h}$	7.109	7.441	0.027
$F^f_{0-9m,d}$	0.125	0.005	0.064
$F^f_{0-9m,h}$	9.931	9.629	0.024
$Q^p_{0-9m,d}$	2.687	2.702	0.028
$Q^p_{0-9m,h}$	2.922	2.914	0.014
E_{0-9m}	0.050	0.027	0.023
Age 10 to 18 months			
Choice 1	0.129	0.135	0.019
Choice 2	0.354	0.371	0.037
Choice 3	0.278	0.245	0.073
Choice 4	0.019	0.021	0.015
Choice 5	0.032	0.034	0.014
Choice 6	0.189	0.193	0.011
$F^p_{10-18m,d}$	3.511	3.532	0.002
$F^p_{10-18m,h}$	9.468	10.154	0.044
$F^f_{10-18m,d}$	0.385	0.102	0.079
$F^f_{10-18m,h}$	12.644	12.345	0.019

Variable	Actual mean	Predicted mean	Abs. diff (in SD)
$Q^p_{10-18m,d}$	2.627	2.610	0.032
$Q^p_{10-18m,h}$	2.941	2.926	0.025
E_{10-18m}	0.036	0.019	0.017
Age 19 to 30 months			
Choice 1	0.189	0.197	0.021
Choice 2	0.338	0.348	0.019
Choice 3	0.258	0.234	0.056
Choice 4	0.036	0.041	0.024
Choice 5	0.031	0.031	0.002
Choice 6	0.148	0.150	0.007
$F^p_{19-30m,d}$	5.448	5.684	0.018
$F^p_{19-30m,h}$	9.274	9.687	0.027
$F^f_{19-30m,d}$	0.526	0.148	0.094
$F^f_{19-30m,h}$	11.397	11.518	0.008
$Q^p_{19-30m,d}$	2.603	2.576	0.058
$Q^p_{19-30m,h}$	2.891	2.877	0.026
E_{19-30m}	0.030	0.013	0.017
Age 31 to 42 months			
Choice 1	0.330	0.328	0.006
Choice 2	0.277	0.282	0.012
Choice 3	0.176	0.165	0.030
Choice 4	0.081	0.086	0.018
Choice 5	0.023	0.024	0.004
Choice 6	0.112	0.115	0.011
$F^p_{31-42m,d}$	8.823	9.164	0.023
$F^p_{31-42m,h}$	7.849	8.157	0.021
$F^f_{31-42m,d}$	0.852	0.398	0.100
$F^f_{31-42m,h}$	11.315	11.406	0.006
$Q^p_{31-42m,d}$	2.757	2.755	0.005
$Q^p_{31-42m,h}$	2.886	2.893	0.014
E_{31-42m}	0.036	0.012	0.025
Age 43 to 57 months			
Choice 1	0.460	0.450	0.020
Choice 2	0.188	0.188	0.001
Choice 3	0.155	0.152	0.007
Choice 4	0.119	0.126	0.023
Choice 5	0.010	0.011	0.007
Choice 6	0.068	0.073	0.017
$F^p_{43-57m,d}$	11.806	12.124	0.021
$F^p_{43-57m,h}$	5.506	5.446	0.005

Variable	Actual mean	Predicted mean	Abs. diff (in SD)
$F^f_{43-57m,d}$	2.290	2.196	0.013
$F^f_{43-57m,h}$	12.201	11.991	0.015
$Q^p_{43-57m,d}$	3.027	3.024	0.004
$Q^p_{43-57m,h}$	2.979	2.970	0.017
E_{43-57m}	0.000	-0.009	0.009
Test scores			
C^B_{WJMS}	91.729	90.874	0.046
C^B_{WJIW}	96.660	96.066	0.044
C^B_{WJPV}	100.270	99.481	0.053
C^B_{WJLW}	98.942	98.243	0.052
C^B_{WJAP}	102.960	102.030	0.060

Note: The absolute difference in standard deviations is calculated after dividing the absolute value of the differences between the actual and the predicted mean by the standard deviation of the observed variable.

Appendix F

Additional tables and figures for the production of cognitive skills

Table F.1: Cognitive scores and unobserved heterogeneity: Statistically significant correlation coefficients

	Number of coefficients	Average value	Max. absolute value: Value	Max. absolute value: Period s
WJ Memory for sentences $\left(\eta^B_{WJMS}\right)$				
$corr\left(\eta^B_{WJMS}, \eta_s^{F^p_d}\right)$	5	-0.353	-0.390	t_{0-9m}
$corr\left(\eta^B_{WJMS}, \eta_s^{F^p_h}\right)$	5	-0.395	-0.467	t_{10-18m}
$corr\left(\eta^B_{WJMS}, \eta_s^{F^f_d}\right)$	4	-0.077	-0.082	t_{43-57m}
$corr\left(\eta^B_{WJMS}, \eta_s^{F^f_h}\right)$	5	0.419	0.477	t_{19-30m}
$corr\left(\eta^B_{WJMS}, \eta_s^{Q^p_d}\right)$	0	–	–	–
$corr\left(\eta^B_{WJMS}, \eta_s^{Q^p_h}\right)$	0	–	–	–
$corr\left(\eta^B_{WJMS}, \eta_s^{E}\right)$	0	–	–	–
$corr\left(\eta^B_{WJMS}, \eta_s^{Q_m}\right)$	3	0.034	0.042	t_{43-57m}
WJ Applied problems $\left(\eta^B_{WJAP}\right)$				
$corr\left(\eta^B_{WJAP}, \eta_s^{F^p_d}\right)$	5	-0.429	-0.474	t_{0-9m}
$corr\left(\eta^B_{WJAP}, \eta_s^{F^p_h}\right)$	5	-0.480	-0.568	t_{10-18m}
$corr\left(\eta^B_{WJAP}, \eta_s^{F^f_d}\right)$	4	-0.094	-0.100	t_{43-57m}

	Number of coefficients	Average value	Max. absolute value	
			Value	Period s
$corr\left(\eta^{B}_{WJAP}, \eta^{F^f_h}_{s}\right)$	5	0.509	0.580	t_{19-30m}
$corr\left(\eta^{B}_{WJAP}, \eta^{Q^p_d}_{s}\right)$	0	–	–	–
$corr\left(\eta^{B}_{WJAP}, \eta^{Q^p_h}_{s}\right)$	0	–	–	–
$corr\left(\eta^{B}_{WJAP}, \eta^{E}_{s}\right)$	0	–	–	–
$corr\left(\eta^{B}_{WJAP}, \eta^{Q_m}_{s}\right)$	4	0.042	0.051	t_{43-57m}
WJ Picture vocabulary $\left(\eta^{B}_{WJPV}\right)$				
$corr\left(\eta^{B}_{WJPV}, \eta^{F^p_d}_{s}\right)$	5	-0.408	-0.451	t_{0-9m}
$corr\left(\eta^{B}_{WJPV}, \eta^{F^p_h}_{s}\right)$	5	-0.457	-0.541	t_{10-18m}
$corr\left(\eta^{B}_{WJPV}, \eta^{F^f_d}_{s}\right)$	4	-0.089	-0.095	t_{43-57m}
$corr\left(\eta^{B}_{WJPV}, \eta^{F^f_h}_{s}\right)$	5	0.484	0.552	t_{19-30m}
$corr\left(\eta^{B}_{WJPV}, \eta^{Q^p_d}_{s}\right)$	0	–	–	–
$corr\left(\eta^{B}_{WJPV}, \eta^{Q^p_h}_{s}\right)$	0	–	–	–
$corr\left(\eta^{B}_{WJPV}, \eta^{E}_{s}\right)$	0	–	–	–
$corr\left(\eta^{B}_{WJPV}, \eta^{Q_m}_{s}\right)$	4	0.040	0.049	t_{43-57m}
WJ Incomplete word $\left(\eta^{B}_{WJIW}\right)$				
$corr\left(\eta^{B}_{WJIW}, \eta^{F^p_d}_{s}\right)$	5	-0.331	-0.366	t_{0-9m}
$corr\left(\eta^{B}_{WJIW}, \eta^{F^p_h}_{s}\right)$	5	-0.371	-0.439	t_{10-18m}
$corr\left(\eta^{B}_{WJIW}, \eta^{F^f_d}_{s}\right)$	4	-0.072	-0.077	t_{43-57m}
$corr\left(\eta^{B}_{WJIW}, \eta^{F^f_h}_{s}\right)$	5	0.393	0.448	t_{19-30m}
$corr\left(\eta^{B}_{WJIW}, \eta^{Q^p_d}_{s}\right)$	0	–	–	–
$corr\left(\eta^{B}_{WJIW}, \eta^{Q^p_h}_{s}\right)$	0	–	–	–
$corr\left(\eta^{B}_{WJIW}, \eta^{E}_{s}\right)$	0	–	–	–
$corr\left(\eta^{B}_{WJIW}, \eta^{Q_m}_{s}\right)$	4	0.032	0.039	t_{43-57m}
WJ Letter-word identification $\left(\eta^{B}_{WJLW}\right)$				
$corr\left(\eta^{B}_{WJLW}, \eta^{F^p_d}_{s}\right)$	5	-0.393	-0.434	t_{0-9m}
$corr\left(\eta^{B}_{WJLW}, \eta^{F^p_h}_{s}\right)$	5	-0.440	-0.521	t_{10-18m}
$corr\left(\eta^{B}_{WJLW}, \eta^{F^f_d}_{s}\right)$	4	-0.086	-0.092	t_{43-57m}
$corr\left(\eta^{B}_{WJLW}, \eta^{F^f_h}_{s}\right)$	5	0.467	0.532	t_{19-30m}
$corr\left(\eta^{B}_{WJLW}, \eta^{Q^p_d}_{s}\right)$	0	–	–	–
$corr\left(\eta^{B}_{WJLW}, \eta^{Q^p_h}_{s}\right)$	0	–	–	–
$corr\left(\eta^{B}_{WJLW}, \eta^{E}_{s}\right)$	0	–	–	–

	Number of coefficients	Average value	Max. absolute value	
			Value	Period s
$corr\left(\eta^{B}_{WJLW}, \eta^{Q_m}_{s}\right)$	4	0.038	0.047	t_{43-57m}

Note: Summary statistics included only for coefficients significant at 1%.
The maximum number of statistically significant coefficients is 5 for all combinations of disturbance terms except for the ones including the measures of parenting quality where that number is 4.

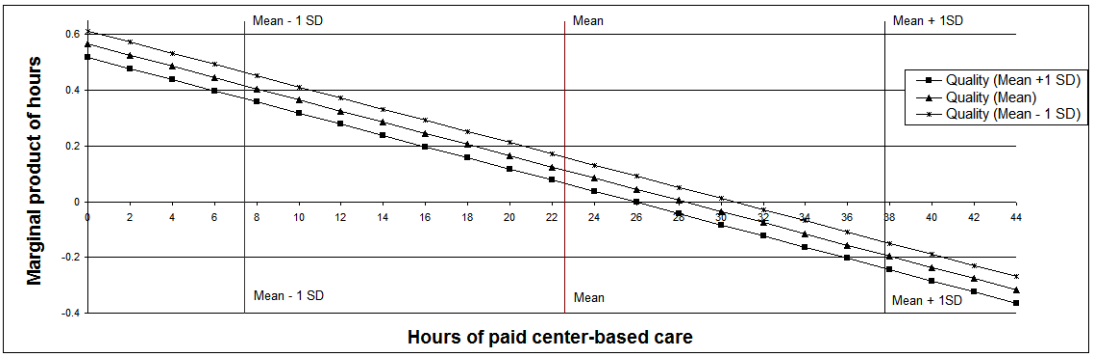

FIGURE F.1: Marginal product of hours of center-based care for cognitive skills for age groups t_{0-9m} and t_{10-18m} keeping other inputs fixed (on yearly basis).

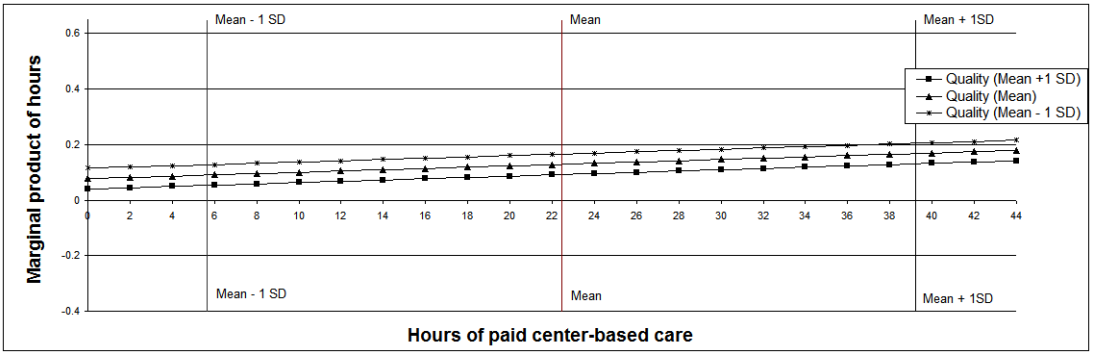

FIGURE F.2: Marginal product of hours of center-based care for cognitive skills for age groups t_{19-30m} and t_{31-42m} keeping other inputs fixed (on yearly basis).

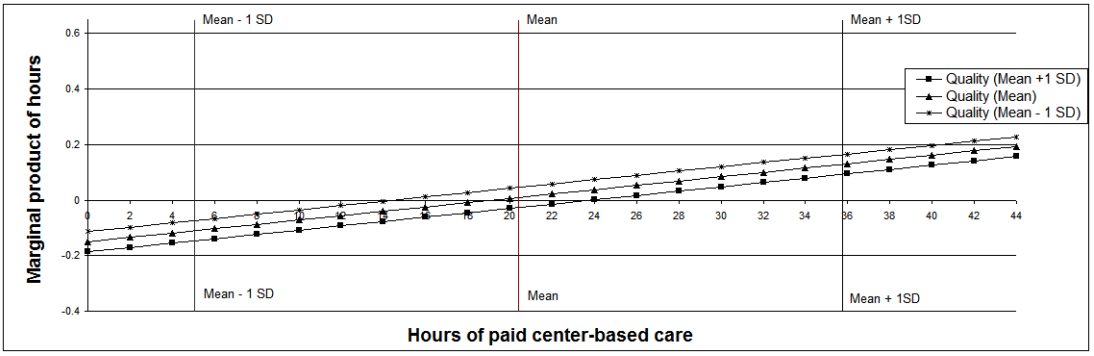

FIGURE F.3: Marginal product of hours of center-based care for cognitive skills for age groups t_{43-57m} keeping other inputs fixed (on yearly basis).

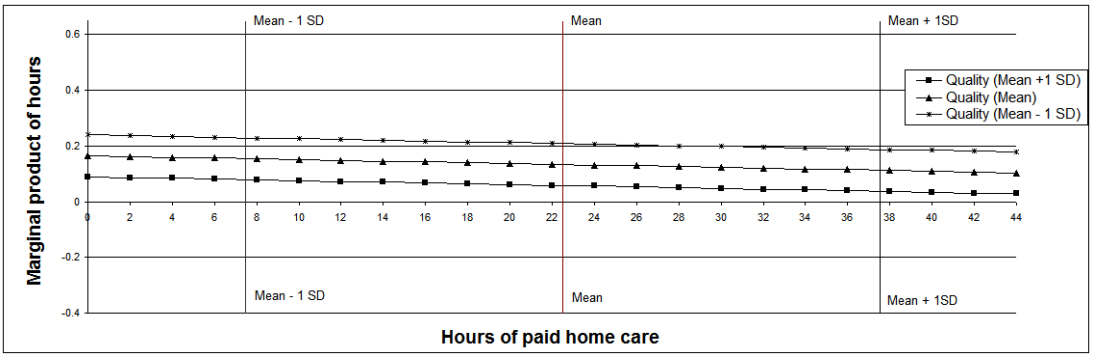

FIGURE F.4: Marginal product of hours of paid home care for cognitive skills for age groups t_{0-9m} and t_{10-18m} keeping other inputs fixed (on yearly basis).

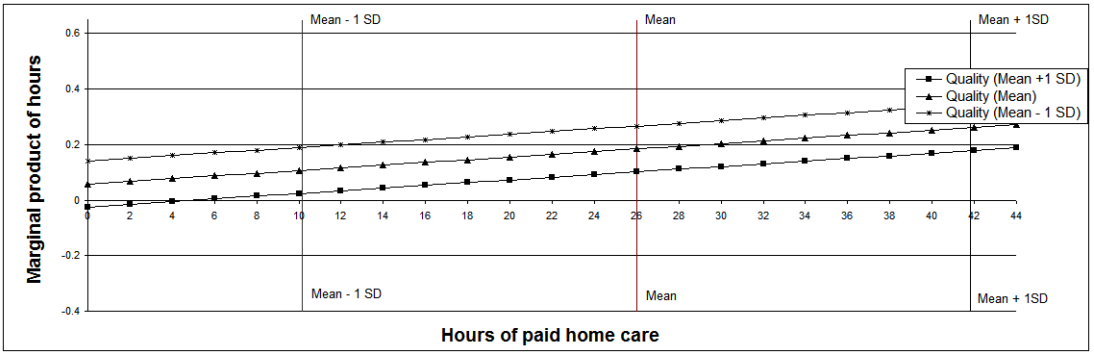

FIGURE F.5: Marginal product of hours of paid home care for cognitive skills for age groups t_{19-30m} and t_{31-42m} keeping other inputs fixed (on yearly basis).

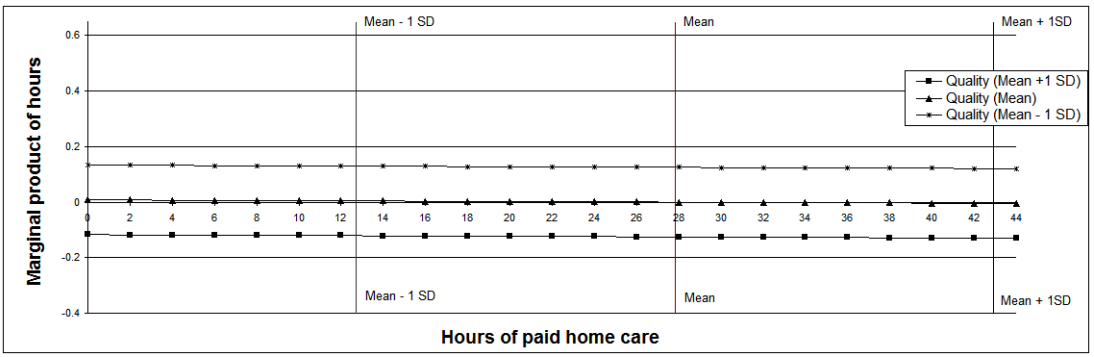

FIGURE F.6: Marginal product of hours of paid home care for cognitive skills for age groups t_{43-57m} keeping other inputs fixed (on yearly basis).

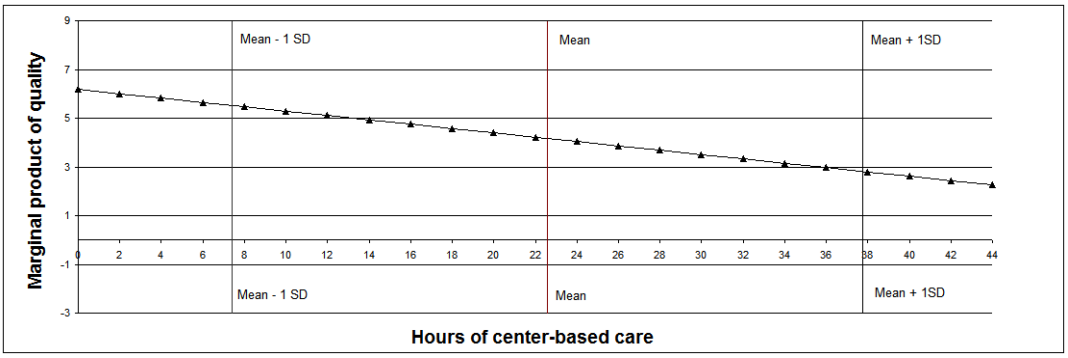

FIGURE F.7: Marginal product of quality of center-based care for cognitive skills for age groups t_{0-9m} and t_{10-18m} keeping other inputs fixed (on yearly basis).

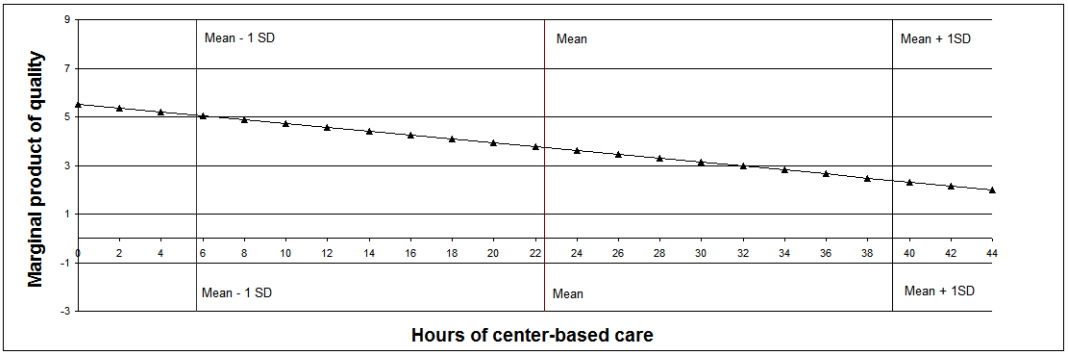

FIGURE F.8: Marginal product of quality of center-based care for cognitive skills for age groups t_{19-30m} and t_{31-42m} keeping other inputs fixed (on yearly basis).

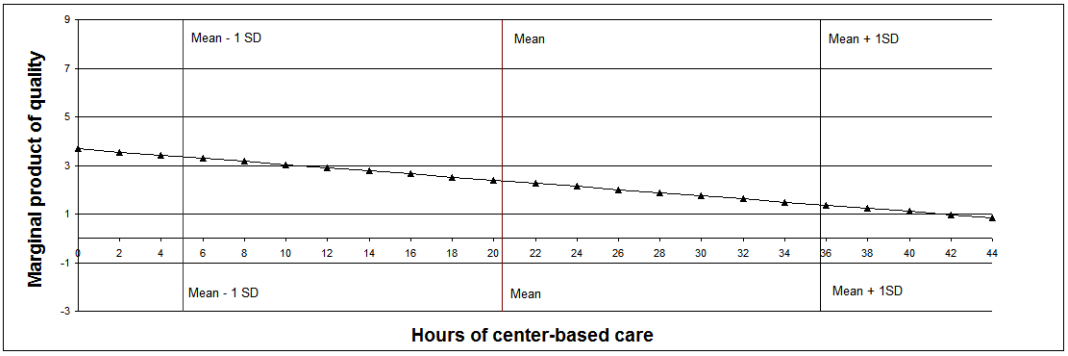

FIGURE F.9: Marginal product of quality of center-based care for cognitive skills for age groups t_{43-57m} keeping other inputs fixed (on yearly basis).

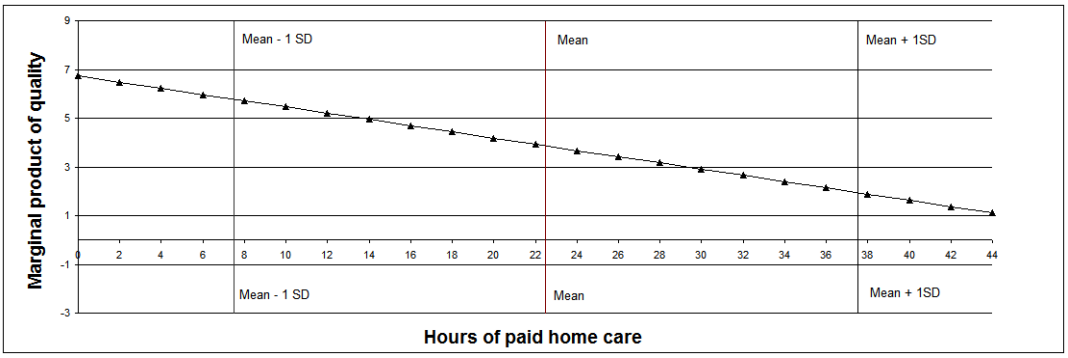

FIGURE F.10: Marginal product of quality of paid home care for cognitive skills for age groups t_{0-9m} and t_{10-18m} keeping other inputs fixed (on yearly basis).

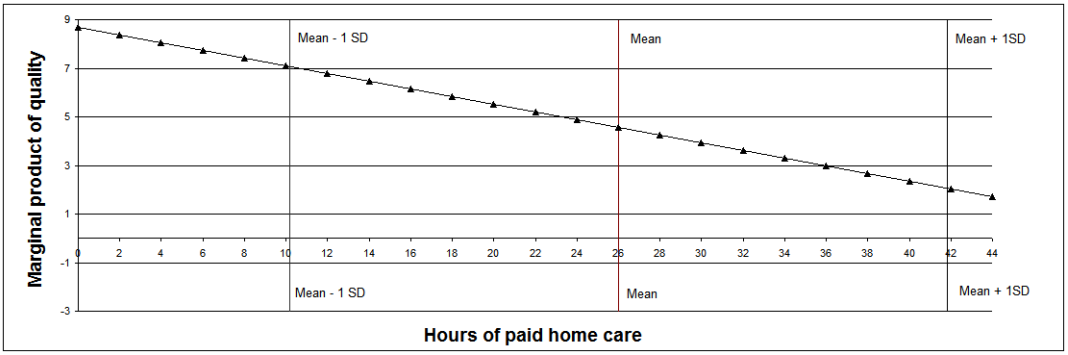

FIGURE F.11: Marginal product of quality of paid home care for cognitive skills for age groups t_{19-30m} and t_{31-42m} keeping other inputs fixed (on yearly basis).

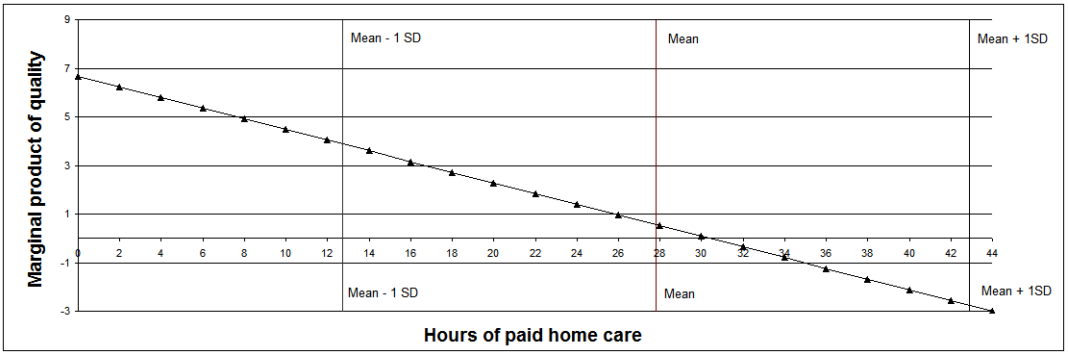

FIGURE F.12: Marginal product of quality of paid home care for cognitive skills for age groups t_{19-30m} and t_{31-42m} keeping other inputs fixed (on yearly basis).

Appendix G

Additional tables of wage rate and childcare price changes

Table G.1: Wage rate and price changes in a single decision period

	t_{0-9m}	t_{10-19m}	t_{19-30m}	t_{31-42m}	t_{43-57m}	All
LW | PC						
Low income	0.189^{**}	0.147^{***}	0.174^{**}	0.151^{**}	0.008	0.735^{***}
Middle income	0.249^{***}	0.159^{***}	0.169^{**}	0.113^{*}	-0.025	0.708^{***}
High income	0.226^{**}	0.101^{**}	0.117	0.028	-0.132^{*}	0.372^{*}
LW | PHC						
Low income	0.169^{**}	0.154^{***}	0.127^{**}	0.067	-0.005	0.548^{***}
Middle income	0.235^{***}	0.175^{***}	0.13^{*}	0.065	-0.02	0.604^{***}
High income	0.228^{**}	0.129^{**}	0.081	0.034	-0.093	0.384^{*}
LW | PDC						
Low income	0.033	0.001	0.07^{*}	0.112^{*}	0.016	0.243^{**}
Middle income	0.032	-0.009	0.062	0.072	-0.009	0.158
High income	0.011	-0.028	0.055	0.004	-0.063	-0.01
LW						
Low income	0.159^{*}	0.11^{**}	0.178^{**}	0.154^{**}	0.004	0.671^{***}
Middle income	0.22^{**}	0.184^{***}	0.17^{**}	0.115^{*}	-0.029	0.717^{***}
High income	0.203^{**}	0.081^{*}	0.118	0.029	-0.132^{*}	0.334

	t_{0-9m}	t_{10-19m}	t_{19-30m}	t_{31-42m}	t_{43-57m}	All
PrHC | Em						
Low income	0.168^{***}	0.129^{***}	0.238^{***}	0.141^{**}	-0.0002	0.713^{***}
Middle income	0.227^{***}	0.153^{***}	0.259^{***}	0.162^{**}	-0.008	0.821^{***}
High income	0.227^{***}	0.143^{***}	0.224^{***}	0.137^{**}	-0.046	0.707^{***}
PrHC						
Low income	0.168^{***}	0.128^{***}	0.242^{***}	0.144^{**}	0.0005	0.719^{***}
Middle income	0.226^{***}	0.152^{***}	0.26^{***}	0.163^{**}	-0.008	0.821^{***}
High income	0.21^{***}	0.138^{***}	0.234^{***}	0.135^{**}	-0.052	0.689^{***}
PrDC | Em						
Low income	0.069^{*}	0.018	0.097^{*}	0.158^{**}	0.089	0.454^{***}
Middle income	0.075	-0.002	0.077	0.134^{**}	0.108	0.411^{***}
High income	0.046	-0.02	0.066	0.072	0.078	0.26^{*}
PrDC						
Low income	0.07^{*}	0.012	0.099^{*}	0.172^{**}	0.083	0.459^{***}
Middle income	0.06	-0.012	0.08	0.147^{**}	0.093	0.389^{**}
High income	0.049	-0.069	0.073	0.096	0.04	0.21
PrC | Em						
Low income	0.219^{***}	0.137^{***}	0.296^{***}	0.265^{***}	0.079	1.084^{***}
Medium income	0.276^{***}	0.139^{***}	0.296^{***}	0.258^{***}	0.09	1.125^{***}
High income	0.25^{***}	0.114^{**}	0.253^{***}	0.178^{**}	0.03	0.883^{***}
PrC						
Low income	0.22^{***}	0.129^{***}	0.302^{***}	0.28^{***}	0.074	1.092^{***}
Medium income	0.261^{***}	0.128^{**}	0.299^{***}	0.271^{***}	0.075	1.103^{***}
High income	0.236^{***}	0.06	0.269^{***}	0.2^{**}	-0.014	0.82^{***}

$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table G.2: Effect on choice variables: changes in wage rates (middle income subsample) versus changes in wage rates (high income subsample)

	LW (Middle income)					LW (High income)				
	Avg. value	Max. absolute value		Min. value		Avg. value	Max. absolute value		Min. value	
		Value	Period	Value	Period		Value	Period	Value	Period
Work	0.051	0.057^{***}	t_{43-57m}	0.047^{***}	t_{19-30m}	0.076	0.104^{***}	t_{43-57m}	0.065^{***}	t_{0-9m}
PaidDC	0.007	0.011	t_{10-18m}	0.002	t_{43-57m}	-0.008	-0.031^{**}	t_{43-57m}	0.008	t_{0-9m}
PaidHC	0.075	0.088^{***}	t_{19-30m}	0.052^{***}	t_{43-57m}	0.064	0.076^{***}	t_{19-30m}	0.038^{***}	t_{43-57m}
F_d^p	0.797	1.431^{***}	t_{43-57m}	0.251^{*}	t_{0-9m}	0.749	1.436^{***}	t_{43-57m}	0.218	t_{0-9m}
F_h^p	2.372	2.77^{***}	t_{19-30m}	1.959^{***}	t_{0-9m}	2.189	2.585^{***}	t_{19-30m}	1.624^{***}	t_{43-57m}
F_d^f	-0.109	-0.398^{***}	t_{43-57m}	0	t_{0-9m}	-0.02	-0.043^{***}	t_{43-57m}	0	t_{0-9m}
F_h^f	-0.193	-0.352^{***}	t_{19-30m}	-0.004	t_{43-57m}	0.168	0.451^{**}	t_{43-57m}	0.022	t_{19-30m}
Q_d^p	-0.028	-0.033^{*}	t_{0-9m}	-0.023	t_{19-30m}	-0.029	-0.037^{*}	t_{0-9m}	-0.02	t_{19-30m}
Q_h^p	-0.028	-0.03	t_{10-18m}	-0.026	t_{0-9m}	-0.024	-0.027	t_{0-9m}	-0.019	t_{19-30m}
E	-0.013	-0.041^{***}	t_{0-9m}	0.015	t_{19-30m}	-0.016	-0.047^{***}	t_{0-9m}	0.012	t_{19-30m}

Note: Avg. value is the average effect for the five periods; Max. absolute value contains the effect with the maximum absolute value and the period in which it is observed; Min. value contains the value of the effect which difference with the max. absolute effect is the greatest and the period in which it is observed.
Changes in hours, quality and home goods are for the expected values.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table G.3: Effect on choice variables: changes in home care prices versus changes in center-based care prices (low income subsample)

	PrHC (Low income)					PrDC (Low income)				
	Avg. value	Max. absolute value		Min. value		Avg. value	Max. absolute value		Min. value	
		Value	Period	Value	Period		Value	Period	Value	Period
Work	0.026	0.029^{***}	t_{31-42m}	0.021^{***}	t_{43-57m}	0.019	0.028^{***}	t_{43-57m}	0.011^{***}	t_{0-9m}
PaidDC	-0.02	-0.033^{***}	t_{43-57m}	-0.006	t_{10-18m}	0.067	0.088^{***}	t_{31-42m}	0.049^{***}	t_{0-9m}
PaidHC	0.068	0.08^{***}	t_{19-30m}	0.054^{***}	t_{10-18m}	-0.017	-0.025^{***}	t_{31-42m}	-0.01	t_{43-57m}
F_d^p	-0.388	-0.615^{**}	t_{43-57m}	-0.085	t_{10-18m}	2.056	3.005^{***}	t_{43-57m}	1.066^{***}	t_{0-9m}
F_h^p	2.15	2.61^{***}	t_{31-42m}	1.555^{***}	t_{0-9m}	-0.403	-0.622^{**}	t_{31-42m}	-0.227	t_{43-57m}
F_d^f	-0.069	-0.264^{***}	t_{43-57m}	0	t_{0-9m}	-0.111	-0.468^{***}	t_{43-57m}	0	t_{0-9m}
F_h^f	-0.234	-0.421^{***}	t_{19-30m}	-0.016	t_{43-57m}	-0.338	-0.474^{***}	t_{31-42m}	-0.16^{***}	t_{0-9m}
Q_d^p	-0.002	-0.002	t_{10-18m}	-0.001	t_{43-57m}	-0.028	-0.03^{*}	t_{10-18m}	-0.023	t_{19-30m}
Q_h^p	0.006	0.008	t_{19-30m}	0.004	t_{10-18m}	-0.002	-0.004^{**}	t_{19-30m}	0.001	t_{0-9m}
E	0.019	0.032^{**}	t_{19-30m}	0.007	t_{43-57m}	0.022	0.052^{***}	t_{43-57m}	-0.01^{*}	t_{0-9m}

Note: Avg. value is the average effect for the five periods; Max. absolute value contains the effect with the maximum absolute value and the period in which it is observed; Min. value contains the value of the effect which difference with the max. absolute effect is the greatest and the period in which it is observed.
Changes in hours, quality and home goods are for the expected values.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table G.4: Effect on choice variables: changes in wage rates versus changes in wage rates conditional on the use paid care (low income subsample)

	LW | PC (Low income)					LW (Low income)				
	Avg. value	Max. absolute value		Min. value		Avg. value	Max. absolute value		Min. value	
		Value	Period	Value	Period		Value	Period	Value	Period
Work	0.051	0.06^{***}	t_{31-42m}	0.044^{***}	t_{0-9m}	0.054	0.061^{***}	t_{31-42m}	0.049^{***}	t_{0-9m}
PaidDC	0.028	0.056^{***}	t_{43-57m}	0.014^{***}	t_{0-9m}	0.023	0.043^{***}	t_{43-57m}	0.012^{**}	t_{0-9m}
PaidHC	0.087	0.099^{***}	t_{19-30m}	0.072^{***}	t_{43-57m}	0.08	0.092^{***}	t_{19-30m}	0.067^{***}	t_{43-57m}
F_d^p	1.091	2.262^{***}	t_{43-57m}	0.3^{***}	t_{0-9m}	0.998	1.999^{***}	t_{43-57m}	0.27^{**}	t_{0-9m}
F_h^p	2.605	2.996^{***}	t_{19-30m}	1.949^{***}	t_{0-9m}	2.46	2.828^{***}	t_{19-30m}	1.824^{***}	t_{0-9m}
F_d^f	-0.249	-1.056^{***}	t_{43-57m}	0	t_{0-9m}	-0.217	-0.891^{***}	t_{43-57m}	0	t_{0-9m}
F_h^f	-0.353	-0.471^{***}	t_{19-30m}	-0.228^{***}	t_{0-9m}	-0.26	-0.422^{***}	t_{31-42m}	-0.115	t_{0-9m}
Q_d^p	-0.027	-0.032^{*}	t_{0-9m}	-0.024	t_{19-30m}	-0.026	-0.032^{*}	t_{0-9m}	-0.023	t_{19-30m}
Q_h^p	-0.029	-0.032^{*}	t_{10-18m}	-0.025	t_{0-9m}	-0.028	-0.03	t_{10-18m}	-0.026	t_{0-9m}
E	-0.001	-0.022^{***}	t_{0-9m}	0.017^{*}	t_{19-30m}	-0.007	-0.036^{***}	t_{0-9m}	0.018	t_{19-30m}

Note: Avg. value is the average effect for the five periods; Max. absolute value contains the effect with the maximum absolute value and the period in which it is observed; Min. value contains the value of the effect which difference with the max. absolute effect is the greatest and the period in which it is observed.
Changes in hours, quality and home goods are for the expected values.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table G.5: Predicted expected values of the choice variables before wage rate or price change

	t_{0-9m}	t_{10-18m}	t_{19-30m}	t_{31-42m}	t_{43-57m}
Low income					
Work	0.731	0.784	0.818	0.817	0.865
PaidDC	0.084	0.113	0.188	0.362	0.475
PaidHC	0.288	0.316	0.311	0.268	0.193
F_d^p	1.592	2.181	4.119	7.501	10.169
F_h^p	5.418	7.947	7.919	7.104	4.987
F_d^f	0.000	0.112	0.180	0.520	3.240
F_h^f	11.542	14.462	13.482	13.272	14.596
Q_d^p	2.696	2.624	2.577	2.738	2.955
Q_h^p	2.778	2.828	2.786	2.774	2.763
E	-0.116	-0.147	-0.232	-0.213	-0.280
Middle income					
Work	0.783	0.839	0.858	0.857	0.882
PaidDC	0.119	0.158	0.240	0.448	0.641
PaidHC	0.386	0.420	0.408	0.333	0.225
F_d^p	2.191	3.272	5.426	9.519	13.524
F_h^p	7.150	10.299	10.108	8.609	5.861
F_d^f	0.000	0.087	0.113	0.205	1.406
F_h^f	10.131	12.997	11.645	11.435	12.151
Q_d^p	2.735	2.659	2.605	2.771	2.997
Q_h^p	2.931	2.956	2.921	2.907	2.946
E	0.211	0.197	0.168	0.168	0.154
High income					
Work	0.702	0.781	0.799	0.800	0.760
PaidDC	0.129	0.170	0.292	0.530	0.800
PaidHC	0.447	0.507	0.466	0.358	0.182
F_d^p	2.030	3.447	6.361	10.638	15.167
F_h^p	7.196	11.081	10.480	8.567	4.521
F_d^f	0.000	0.019	0.068	0.115	0.162
F_h^f	7.544	10.577	9.549	8.906	7.660
Q_d^p	2.748	2.659	2.652	2.831	3.086
Q_h^p	3.012	3.037	3.008	3.026	3.238
E	0.367	0.350	0.405	0.380	0.469

Table G.6: Predicted expected values of the quality of parenting and cognitive skills before wage rate or price change

	Low income	Middle income	High income
Quality of parenting	4.5452	5.5954	6.3517
Cognitive skills	1.2461	6.832	11.878
Memory for Sentences	85.904	91.49	96.535
Incomplete Words	92.652	96.484	99.946
Picture Vocabulary	94.657	100.09	104.99
Letter - Word Identification	94.092	98.758	102.97
Applied Problems	96.608	102.65	108.11

Appendix H

Expected value of cognitive skills for assessment of wage rate and childcare price changes

The logarithm of the wage rate affecting household decisions can be divided in the following way

$$w_t^* = \widetilde{w_t^*} + \boldsymbol{X_t^{w\prime}}\boldsymbol{\beta_w'} + \boldsymbol{X_t^{w\prime\prime}}\boldsymbol{\beta_w''} + \sum_{a'=1}^{a} \rho_{a'}^{w_t}\theta_{a'},$$

where $\widetilde{w_t^*}$ is a component determined by the market and unrelated to the individual characteristics of the mother, $\boldsymbol{X_t^{w\prime}}$ are variables accounting for the human capital of the mother before birth that are not included in the characteristics affecting her preferences or determined endogenously in the model (i.e., employment in the previous period), and $\boldsymbol{X_t^{w\prime\prime}}$ are all other individual-specific determinants of the wage rate. That allows us to denote the set of exogenous individual characteristics in period t as

$$\widetilde{\boldsymbol{\Delta_t}} \equiv \left\{\boldsymbol{X_t^U}, \boldsymbol{StF_t^g}, M_t, Y_t^k, Y_t^o, \boldsymbol{X_t^{w\prime}}\right\}$$

and the set of exogenous market variables as $\widetilde{\boldsymbol{\Psi_t}}$. The definition of $\widetilde{\boldsymbol{\Psi_t}}$ follows closely the one for $\boldsymbol{\Psi_t}$ in table 3.1, with the overall wage rate w_t^* being replaced by the

market component $\widetilde{w_t^*}$. We further denote the set of the idiosyncratic shocks for hours of free center-based care and hours of free home care as $\widetilde{\boldsymbol{\epsilon_t^f}} = \left\{ \epsilon_t^{F_d^f}, \epsilon_t^{F_h^f} \right\}$. The set of exogenous household characteristics for all periods is

$$\overline{\boldsymbol{\Delta}} = \left\{ \boldsymbol{X^B}, \boldsymbol{X^{Q_m}}, \widetilde{\boldsymbol{\Delta_{0-9m}}}, \widetilde{\boldsymbol{\Delta_{10-18m}}}, \widetilde{\boldsymbol{\Delta_{19-30m}}}, \widetilde{\boldsymbol{\Delta_{31-42m}}}, \widetilde{\boldsymbol{\Delta_{43-57m}}} \right\}$$

and similarly for the market variables and the idiosyncratic shocks we have:

$$\overline{\boldsymbol{\Psi}} = \left\{ \widetilde{\boldsymbol{\Psi_{0-9m}}}, \widetilde{\boldsymbol{\Psi_{10-18m}}}, \widetilde{\boldsymbol{\Psi_{19-30m}}}, \widetilde{\boldsymbol{\Psi_{31-42m}}}, \widetilde{\boldsymbol{\Psi_{43-57m}}} \right\} \text{ and}$$

$$\overline{\boldsymbol{\epsilon^f}} = \left\{ \widetilde{\boldsymbol{\epsilon^f_{0-9m}}}, \widetilde{\boldsymbol{\epsilon^f_{10-18m}}}, \widetilde{\boldsymbol{\epsilon^f_{19-30m}}}, \widetilde{\boldsymbol{\epsilon^f_{31-42m}}}, \widetilde{\boldsymbol{\epsilon^f_{43-57m}}} \right\}.$$

For each income group we use the average values of the household characteristics $\overline{\boldsymbol{\Delta^{Inc}}}$, where $Inc \in$ {Low income, Middle income, High income} denotes the subsample of married mothers in the first, third and fifth quintiles of the distribution of the husbands' incomes. The values of $\overline{\boldsymbol{\epsilon^f}}$ are set to their means $\overline{\boldsymbol{\epsilon^f_{EV}}}$ or zero. If $\overline{J}$ is the set of all possible combination of modes the household could have chosen across the five periods (6 states to the power 5 periods=7776), using the law of iterated expectations and the fact that the unobservable discretized[1] θ is independent of those exogenous variables, the expected value of cognitive skills can be expressed in the following way:

$$\begin{aligned}
\mathrm{E}\left[B_{57m}|\overline{\boldsymbol{\Delta^{Inc}}}, \overline{\boldsymbol{\Psi}}, \overline{\boldsymbol{\epsilon^f_{EV}}}\right] &= \mathrm{E}_{\overline{J},\theta|\overline{\boldsymbol{\Delta^{Inc}}},\overline{\boldsymbol{\Psi}},\overline{\boldsymbol{\epsilon^f_{EV}}}}\left[\mathrm{E}\left[B_{57m}|\overline{\boldsymbol{\Delta^{Inc}}}, \overline{\boldsymbol{\Psi}}, \overline{\boldsymbol{\epsilon^f_{EV}}}, \overline{J}, \theta\right]|\overline{\boldsymbol{\Delta^{Inc}}}, \overline{\boldsymbol{\Psi}}, \overline{\boldsymbol{\epsilon^f_{EV}}}\right] \\
&= \sum_{\theta^*}\sum_{J^*}\left(\mathrm{E}\left[B_{57m}|\overline{\boldsymbol{\Delta^{Inc}}}, \overline{\boldsymbol{\Psi}}, \overline{\boldsymbol{\epsilon^f_{EV}}}, J^*, \theta^*\right] Pr\left(\overline{J} = J^*, \theta = \theta^*|\overline{\boldsymbol{\Delta^{Inc}}}, \overline{\boldsymbol{\Psi}}, \overline{\boldsymbol{\epsilon^f_{EV}}}\right)\right) \\
&= \sum_{\theta^*}\sum_{J^*}\left(\mathrm{E}\left[B_{57m}|\overline{\boldsymbol{\Delta^{Inc}}}, \overline{\boldsymbol{\Psi}}, \overline{\boldsymbol{\epsilon^f_{EV}}}, J^*, \theta^*\right] Pr\left(\overline{J} = J^*|\overline{\boldsymbol{\Delta^{Inc}}}, \overline{\boldsymbol{\Psi}}, \overline{\boldsymbol{\epsilon^f_{EV}}}, \theta^*\right)\right) Pr(\theta^*).
\end{aligned}$$

$\mathrm{E}\left[B_{57m}|\overline{\boldsymbol{\Delta^{Inc}}}, \overline{\boldsymbol{\Psi}}, \overline{\boldsymbol{\epsilon^f_{EV}}}, J^*, \theta^*\right]$ can be represented as a linear function of the expected values of the childcare characteristics associated with the state J^*, θ^* and

[1] We use a Gauss-Hermite quadrature with 7 mass points for integrating out θ.

the observables determining B_{57} and the variances of the idiosyncratic shocks for the hours of paid center-based care and paid home care. The estimate of interest $\mathrm{E}\left[B_{57m}|\overline{\boldsymbol{\Delta}^{\boldsymbol{Inc}}}, \overline{\boldsymbol{\Psi}}, \overline{\boldsymbol{\epsilon}^{\boldsymbol{f}}_{\boldsymbol{EV}}}\right]$ is obtained after taking a weighted sum of all those expected values and the analyzed effect of a change in market variables from $\overline{\boldsymbol{\Psi}}$ to $\overline{\boldsymbol{\Psi}}'$ on the expected value of the cognitive skills becomes:

$$Eff(\overline{\boldsymbol{\Psi}} \rightarrow \overline{\boldsymbol{\Psi}}') = \mathrm{E}\left[B_{57m}|\overline{\boldsymbol{\Delta}^{\boldsymbol{Inc}}}, \overline{\boldsymbol{\Psi}}', \overline{\boldsymbol{\epsilon}^{\boldsymbol{f}}_{\boldsymbol{EV}}}\right] - \mathrm{E}\left[B_{57m}|\overline{\boldsymbol{\Delta}^{\boldsymbol{Inc}}}, \overline{\boldsymbol{\Psi}}, \overline{\boldsymbol{\epsilon}^{\boldsymbol{f}}_{\boldsymbol{EV}}}\right],$$

where the changes in the market variables ι^{w}_{t} and $\iota^{p_c}_{t}$ for $\overline{\boldsymbol{\Psi}}'$ regarding each particular effect are defined as

$$\widetilde{w^{*}_{t}}' = \begin{cases} \widetilde{w^{*}_{t}} + \iota^{w}_{t}, & \text{if the condition related to the state } J_t \text{ is satisfied} \\ \widetilde{w^{*}_{t}}, & \text{otherwise} \end{cases}$$

and

$$p^{*\prime}_{tc} = \begin{cases} p^{*}_{tc} - \iota^{p_c}_{t}, & \text{if the condition related to the state } J_t \text{ is satisfied} \\ p^{*}_{tc}, & \text{otherwise} \end{cases}$$

with $c \in \{d, h\}$. The p values for $Eff(\overline{\boldsymbol{\Psi}} \rightarrow \overline{\boldsymbol{\Psi}}')$ are obtained using the the covariance matrix from the maximum likelihood estimation procedure.

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Biography

Vladislav Valeriev Slanchev was born on June 23rd, 1981 in Sofia, Bulgaria. He attended First English Language School in Sofia and later on got his Bachelor of Arts degree in Economics from Sofia University in 2004. In 2006 he received his Master of Arts degree in Economics from Central European University in Budapest, Hungary. He also holds a Master of Arts degree in Economics from Duke University, North Carolina, which he obtained in 2008.

During his graduate studies he received numerous fellowships: Central European University Fellowship, 2004 – 2006; Duke University, Economics Department Graduate Fellowship, 2006 – 2007; Duke University, Graduate School Research Summer Fellowship, 2009; Duke University, Program for Advanced Research in the Social Sciences Fellowship, 2011 – 2012. He is one of the co-authors in Angelov et al. (2004). After receiving his PhD in Economics from Duke University he is planning to accept a post-doctoral associate position at the Duke University Population Research Center.